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Railless electric traction from the point of view of its economic results (1),

by FELICE CORINI,

Engineer, Professor at the Royal School of Engineering, at Bologna (Italy).

I. — Foreword.

Railless electric traction is carried out in two definite ways : electric traction with accumulators, and electric traction with the power transmitted by means of a double trolley wire above the road.

The first method has against it the well-known difficulties inherent to the weight of the accumulators to be carried, and its field of application is limited not only from the financial point of view but also by purely technical reasons, relative to the suitability of this method of transport for conveying large masses at high speeds (2).

In its second form railless electric traction is capable from the technical point of view of giving very good results, in every way equivalent to those to be obtained with tramways and motor vehicles. The question we have to consider is to see if, from this point of view, this form of transport has its own particular field of use and what are its limits.

The problem has particular interest today, seeing that the applications in Europe and America (3), (namely in England and the United States) are numerous and that there is a tendency to substitute railless electric traction for tramways the operating results of which are unfavourable. Should this tendency be encouraged, or on the contrary should it be resisted ? We will answer this question by finding a solution to the more general problem, that of deciding the economic limits of the field of application of railless electric traction.

We will follow in this investigation the method we have applied previously in in-

(1) Translated from the Italian.

(2) See: CORINI, « Costruzione ed esercizio delle Ferrovie » (*Construction and operation of railways*), vol. IV : « Electric traction ».

(3) Cfr. Ing. PIAZZA : « La Filovia come mezzo di trasporto per le masse » (The electric road vehicle as a method of mass transport), *Elettrotecnica*, 1931, No. 31.

vestigations of the same kind (4); we will calculate the cost price of the unit of traffic for the three methods of transport : electric tramway, railless electric road vehicle, road motor vehicle, and we will indicate in which cases the cost of the traffic unit by railless electric vehicles is lower than that of the unit of traffic by tramway and by road motor vehicle.

II. — Cost of the virtual ton-kilometre in the three systems considered.

The problem which occupies us is to determine the cost price of the passenger kilometre and of the ton-kilometre; to arrive at this it is necessary to take into account the use made of the seats available and of the loading capacity offered as well as of the tare weight per passenger and per ton of goods.

These elements vary considerably from one line to another; we will first determine therefore the cost of the virtual ton-kilometre in each of the three cases.

We will then deal with the cost of the unit of traffic on the basis of the average figures of utilisation and of tare.

Cost of the virtual ton-kilometre by tramway.

Supposing the tramway to be laid entirely on an ordinary road in order to make the conditions of construction the same for the three methods of transport to be compared, we have to consider the following elements in the cost price :

I. — *Expenditure relative to the fixed plant of the tramways.*

a) *Tracks and stations.*

Let A be the cost of the track per kilometre increased by the proper proportion of the cost of the stations per kilometre of line.

Let r_1 be the annual charges including interest, sinking fund, renewal, and r_2 the cost of maintenance. The annual expenditure per km. of line will then be : $(r_1 + r_2)$ A.

If τ be the number of virtual ton-kilometres (tkm.) per km. of the tramway line under consideration, the above expenditure related to the virtual tkm. unit will be :

$$\frac{(r_1 + r_2)\,A}{\tau}.$$

b) *Electrification equipment.*

Let I be the cost of the electrification equipment related to the kilometre of line electrified. The cost per km. of line will be $\nu \cdot I$, ν being the ratio between the development of the electrified tracks and the length of the line. If r_1' and r_2' be the annual charges and the maintenance charges respectively, the relative expenditure of the electrification equipment per virtual tkm. will be :

$$\frac{r'_1 + r_2}{\tau} \cdot \nu \cdot I.$$

II. — *Management, administration, operating and traffic charges, not including train staff.*

These costs can be taken as being constant per km. of line. If they be represented by M, the expenditure under this head per virtual tkm. will be : $\frac{M}{\tau}$.

III. — *Traction and train staff costs.*

a) The traction costs per virtual tkm. can be divided in their turn into energy costs and rolling stock costs.

The energy costs, if e be the number of watt-hours (w.-h.) per virtual tkm.

(4) Cfr. work by the same author quoted in footnote (1), vol. V : « Movement and traffic and economic questions », Chapter X.

and E the price of the kw.-h., are represented by $10^{-3} \cdot e \cdot E$.

Let σ represent rolling stock costs per virtual tkm. These include expenditure on interest on the capital corresponding to the cost of the rolling stock and the maintenance thereof, related to the virtual tkm.

b) The driving costs and the train staff costs of the electric tramway trains can be considered per virtual tkm. and as a whole be indicated by p. This hypothesis implies that the tramway trains are always made up to the same strength.

To sum up, the cost of the virtual tkm. by tramway can be expressed as follows :

$$C_1 = (r_1 + r_2)\frac{A}{\tau} + (r'_1 + r'_2)\frac{\nu \cdot I}{\tau} + \frac{M}{\tau} + 10^{-3} \cdot e \cdot E + \sigma + p. \quad (1)$$

Cost of the virtual tkm. of railless electric trains (motor vehicle or motor vehicle and trailer).

I. — *Fixed plant.*

a) *Permanent way and sheds.*

Although no special permanent way is required on the ordinary road when operating a railless electric line, a share of the cost of construction and maintenance of the road surface must be considered as being a debit to this line. If A′ be the cost of construction of a section of the road surface 1 km. long and 2 m. wide, and R_1 the charges including interest and sinking fund, R_2 the costs of maintenance, the expenditure per virtual tkm. becomes $\frac{1}{n}(R_1 + R_2)\frac{A'}{\tau}$, when $\frac{1}{n}$ is the fraction of the cost to be borne by the railless electric service and τ retains the value already used in the preceding case to represent the traffic in virtual tkm. per km. of line.

In order to take into account all the expenditure relating to the construction and maintenance of the sheds, the coefficient $\mu > 1$ will be introduced and we then get :

$$\frac{\mu}{n}(R_1 + R_2)\frac{A'}{\tau}.$$

b) *Electrification equipment.*

We shall have an expression similar to that arrived at in the case of the tramway, i. e.:

$$(R'_1 + R'_2)\frac{\nu \cdot I'}{\tau}.$$

II. — *Management, administration, operating and traffic charges, not including train staff.*

As in the preceding case, the charges can be expressed by $\frac{M'}{\tau}$.

III. —*Traction and train staff costs.*

As in the preceding case we shall have $10^{-3} \cdot e' \cdot E$ for the traction cost, *e′ being* the number of watt-hours required per virtual tkm. on an ordinary road, and $\sigma' + p'$ for the costs of the rolling stock and the train staff of the railless electric trains.

As total we get :

$$C_2 = \frac{\mu}{n}(R_1 + R_2)\frac{A'}{\tau} + (R'_1 + R'_2)\frac{\nu' \cdot I'}{\tau} + \frac{M'}{\tau} + 10^{-3} \cdot e' \cdot E + \sigma' + p' \quad (2)$$

Cost of the virtual tkm. of the motor omnibus.

I. — *Fixed plant.*

Permanent way and shed.

The expenditure does not differ from

that involved in the case of railless electric traction and can be expressed by :

$$\frac{\mu}{n}(R_1 + R_2)\frac{A'}{\tau}.$$

II. *Administration and operating costs.*

These do not differ from those for railless electric traction and are consequently expressed by $\frac{M'}{\tau}$.

III. *Traction and train staff costs.*

If we let b indicate the number of kgr. of petrol per virtual tkm., B the price per kgr. of petrol, the cost of fuel will be given by b.B.

We shall have in addition : σ'' the expenditure relative to the rolling stock and p' the costs of drivers and conductors equal to those in the preceding case.

We then have :

$$C_3 = \frac{\mu}{n}(R_1 + R_2)\frac{A'}{\tau} + \frac{M'}{\tau} + b \cdot B + \sigma'' + p' \quad (3)$$

III. — Comparison between the railless electric road vehicle and the road motor omnibus.

We will limit the comparison to the single case of practical interest, i. e. to the passenger service.

Let π be the weight in tons on the railless electric motor vehicle, and π' the weight of the motor omnibus, γ and γ' respectively the number of seats. If the coefficient of use of the seats available is in both cases $\frac{1}{u}$, the tare weight per passenger is respectively $u\frac{\pi}{\gamma}$ and $u\frac{\pi'}{\gamma'}$ tons. If the average weight of the passenger is 0.07 ton the total weight of the electric motor vehicle and of the motor omnibus will be respectively $u\frac{\pi}{\gamma} + 0.07$ and $u\frac{\pi'}{\gamma'} + 0.07$ ton.

The cost price per virtual passenger-km. of the railless electric motor vehicle will be :

$$V_f = \left(u\frac{\pi}{\gamma} + 0.07\right) \cdot C_2 \quad . \quad . \quad (4)$$

and that per virtual passenger-km. on the road motor vehicle :

$$V_a = \left(u\frac{\pi'}{\gamma'} + 0.07\right) \cdot C_3 \quad . \quad . \quad (5)$$

Conveyance by railless electric vehicle will be cheaper than by road motor omnibus if we have :

$$V_f < V_a \quad . \quad . \quad . \quad . \quad (6)$$

Taking account of formulæ (2), (3), (4), and (5), we find the expression (6) becomes :

$$\left(u\frac{\pi}{\gamma} + 0.07\right)\left[\frac{\frac{\mu}{n}(R_1 + R_2)A' + \nu'(R'_1 + R'_2)I' + M'}{\tau} + 10^{-3} \cdot e' \cdot E + \sigma' + p'\right]$$

$$< \left(u\frac{\pi'}{\gamma'} + 0.07\right)\left[\frac{\frac{\mu}{n}(R_1 + R_2)A' + M'}{\tau} + b \cdot B + \sigma'' + p'\right] \quad . \quad . \quad . \quad (7)$$

If $\frac{\pi}{\gamma}$ be taken as equal to $\frac{\pi'}{\gamma'}$, then the formula (7) becomes :

$$\frac{\nu'(R'_1 + R'_2)I'}{\tau} + 10^{-3} \cdot e' \cdot E + \sigma' < b \cdot B + \sigma'' \quad . \quad . \quad . \quad . \quad (8)$$

In consequence, condition (6) is met, in other words the railless electric line must be preferred when :

$$\tau > \frac{\nu' (R'_1 + R'_2) I'}{b \cdot B - 10^{-3} \cdot e' \cdot E + \sigma'' - \sigma'} \quad (9)$$

The traffic intensity in virtual tkm. per km.:

$$\tau_l = \frac{\nu' (R'_1 + R'_2) I'}{b \cdot B - 10^{-3} \cdot e' \cdot E + \sigma'' - \sigma'} \quad (10)$$

represents the intensity of the limiting traffic below which the motor omnibus service is the better; above it railless electric traction is to be preferred.

In order to determine the value of τ_l it is as well to consider the value of the different elements entering into the expression (10).

The cost of the contact line for a railless electric service evidently exceeds that of a tramway. If in the latter case the cost can be taken as 45 000 lire per km. of single track, for the former a cost of 70 000 lire per km. also for single track with overhead line must be allowed.

If the electrification equipment of a single track tramway including the substations and the feeder lines represents an expenditure per km. of 120 000 to 150 000 lire, i. e. an average of 135 000 lire, the cost of the electrification equipment of a railless electric line lies between 145 000 and 175 000 lire per km. and on the average is 160 000 lire, so that we can write :

$$I' = 160\,000 \text{ (lire)}.$$

We can also take :

$$\nu' = 1.20;$$
$$r'_1 = 7\ \%;$$
$$r'_2 = 4\ \%.$$

Let us now determine the values of e' and b.

Let us suppose that the operation is in both cases at a speed of 30 km. per hour on straight and level line.

The resistance on straight level line per metric ton of a motor omnibus is given by :

$$r = a + bV^2 (6)$$

in which :

a = the resistance in kgr. per metric ton, not including air resistance,

$$b = 0.0000142 + 0.00592 \frac{S}{Q},$$

S = cross section of the motor vehicle in square metres.

V = speed in km. per hour.

Q = weight of the motor vehicle in metric tons.

On a good macadam road we have :

$$a = 20 \text{ kgr. per ton.}$$

On an asphalt road :

$$a = 15 \text{ kgr. per ton.}$$

Let us take the latter value.

Supposing $\frac{S}{Q} = 1$, when V = 30 km. per hour = 8.3 m. per second, we find :

$$bV^2 = 5 \text{ kgr. per ton,}$$

whence : r = approx. 20 kgr. per ton.

The work equivalent to a ton weight over one kilometre on the level is given by:

L = r. s. = 20 000 kilogramme-metres (Kgr.-M.).

Let us suppose there is a halt every 200 m., and consequently 5 starts per km. If we take the final speed of each portion of run with current off as V = 15 km. an hour = 4.1 m. per second, we find that the energy used at the 5 starts mentioned above less the energy regen-

(6) Cfr. « Meccanica della locomozione », pp. 25 and 27.

erated in the five corresponding coasting phases is given by :

$$L_2 = 5 \cdot \frac{1}{2} m V^2 = \frac{5}{2} \cdot \frac{1\,000}{g} \cdot \overline{4.1^2}$$

whence :

$$L_2 = \sim 3\,800 \text{ Kgr.-M.}$$

The energy per virtual tkm. is therefore :

$$L = L_1 + L_2 = 23\,800 \text{ Kgr.-M.} = 233\,478 \text{ joules}$$

or I = 65 w.-h. Taking 0.60 as the coefficient of overall efficiency from the high tension bus bars to the wheels we have : $e' = 108$ w.-h.

Supposing the consumption of an internal combustion motor of a motor vehicle is 0.26 kgr. per indicated H. P.-hour, and that the overall coefficient of efficiency is 0.86 we have :

$$L' = \frac{65}{0.86} = 75 \text{ w.-h.}$$

$b = 0.02621$ kgr. of petrol.

We can take :

E = 0.15 lira per kw.-h.,

B = 1.60 lire per kgr.,

which corresponds to petrol at 1.2 lire per litre. To take into acount the recent rise in price we will also take into consideration the value $B_2 = 2.40$ lire per kgr.

The cost for tyres and repairs per virtual omnibus-km. can be calculated on a mean of 0.90 lira corresponding to 0.128 lira per virtual tkm.

The interest and sinking fund charges per motor-omnibus-km. can be taken as 0.75 lira corresponding to 0.107 lira per tkm. In all $\sigma'' = 0.235$ lira.

The corresponding value for the railless electric vehicles is appreciably lower.

According to American statistics, the difference is about 0.055 lira and consequently $\sigma'' = 0.18$ lira.

When $B_1 = 1.60$ lire per kgr. we have:

$$\tau_l = 260\,740 \frac{\text{virtual tkm. per annum}}{\text{per km.}}$$

whence :

$$\tau_l = 724 \frac{\text{virtual tkm. per day}}{\text{per km.}}$$

or again :

$$\tau_l = 100 \frac{\text{vehicle-km. per day}}{\text{per km.}}.$$

In other words the traffic must be sufficient to justify running 50 pairs of motor omnibuses each day : that is to say if the traffic offers between 6 a. m. to 8 p. m., i. e. during 14 hours, the departures take place every 17 minutes in both directions.

When $B_2 = 2.40$ lire, the value of T is about 8/10 of the preceding case and consequently the interval between vehicles in each direction is about 21 minutes.

This is rather a large traffic and one hardly likely to be found on outer suburban lines, but only on inner suburban or urban lines.

IV. — Comparison between the tramway and the railless electric vehicle.

Let π_1'' be the weight of a tramway coach of capacity γ_1'' and π_2'' and γ_2'' respectively the weight and capacity of a trailer.

If a tramway train be taken as composed of a motor coach and trailer and if $\frac{1}{u'}$ be the coefficient of utilisation of the available seats, we see that the weight per passenger is given by :

$$\frac{u'}{2}\left(\frac{\pi''_1}{\gamma''_1}+\frac{\pi''_2}{\gamma''_2}\right)+0.07.$$

The cost price per passenger km. is :

$$V_t=\left[\frac{u'}{2}\left(\frac{\pi''_1}{\gamma''_1}+\frac{\pi''_2}{\gamma_2''}\right)+0.07\right]C_1 \quad (11)$$

The transport by railless electric vehicle will be better than by tramway when :

$$V_f < V, \quad (12)$$

when :

$$\left(u\frac{\pi}{\gamma}+0.07\right)\left[\frac{\frac{\mu}{n}(R_1+R_2)A'+\nu'(R'_1+R'_2)I'+M'}{\tau}+10^{-3}\cdot e'\cdot E+\sigma'+p'\right]<$$

$$<\left[\frac{u'}{2}\left(\frac{\pi''_1}{\gamma''_1}+\frac{\pi''_2}{\gamma''_2}\right)+0.07\right]\cdot\left[\frac{(r_1+r_2)A+\nu(r'_1+r'_2)I+M}{\tau}+10^{-3}\cdot e\cdot E+\sigma+p\right]$$

and whence :

$$\tau<\frac{b(r_1+r_2)A-a\frac{\mu}{n}(R_1+R_2)A'+b\nu(r'_1+r'_2)I-a\nu'(R'_1+R'_2)I'+bM-aM'}{10^{-3}\cdot E(ae'-be)+a\sigma'-b\sigma+ap'-bp} \quad (13)$$

after taking :

$$u\frac{\pi}{\gamma}+0.07=a$$

and

$$\frac{u'}{2}\left(\frac{\pi''_1}{\gamma''_1}+\frac{\pi''_2}{\gamma''_2}\right)+0.07=b.$$

The limiting value τ'_l will be given by the second member of equation (13).

In order to determine the value of τ'_l let us fix the value of the elements making up the second member of equation (13).

If $\pi = 7$ t., $\gamma = 31$, $\frac{1}{u}=\frac{1}{5}$, we have :

$$a = 1.20 \text{ metric ton.}$$

In the case of the motor vehicle we can make $\frac{\pi''_1}{\gamma''_1}=0.333$ ton, and the trailer $\frac{\pi''_2}{\gamma''_2}=0.17$ ton.

Taking $\frac{1}{u'}=\frac{1}{u}=\frac{1}{5}$, we have :

$$b = 1.10 \text{ ton.}$$

If a motor vehicle alone were considered we should have had $b = 1.73$.

The average of b in the two cases would be 1.40, that is to say higher than the value of a.

For a preliminary calculation we can make $a = b$, and we can also take A = 150 000 lire per km.

Taking the life of rails at 50 years, we have : $r_1 = 5.47$ %.

For the maintenance costs, we can suppose $r_2 = 1.53$ %.

We get thereby : $r_1 + r_2 = 7$ %.

A section of road surface made of a concrete and asphalt conglomerate 2 m. wide and 1 km. long may cost about 50 000 lire.

If the traffic by railless electric vehicle on the 2-m. wide section considered is half the total traffic of the line, by making $\mu = 1.10$:

$$\frac{\mu}{2} A' = 27\,500 \text{ lire.}$$

The life of the road surface being taken as equal to 20 years we have :

$$R_1 = 0.080.$$

We also admit that $R_2 = 0.027$, whence $R_1 + R_2 = 0.107$.

Let us make :

$$r'_1 = R'_1 = 7\ \%,$$
$$r'_2 = R'_2 = 4\ \%,$$
$$\nu = \nu' = 1.2,$$
$$I = 135\,000,$$
$$I' = 160\,000.$$

In general we find $M > M'$; let us take for the preliminay calculation, $M = M'$. We have also $e' = 108$ w.-h. as found in the previous case. By the same method and again taking 5 starts per km., we have :

$$r = 2.5 + bV^2.$$

We can consider the second term as equal to that adopted for the railless electric vehicle by using 5 kgr. per ton for the motor vehicle and 1/3 of this value or 1.7 kgr. per ton for the trailer.

The average will give :

$$bV^2 = \frac{(2 \times 5) + 1.7}{3} = 3.9 \text{ kgr. per ton.}$$

We get from this :

$$r = 6.4 \text{ kgr. per km.}$$
$$L_1 = 6\,400 \text{ Kgr.-M.}$$

Still supposing 5 starts per km. and the speed at the end of the run with current off as 15 km. an hour we have :

$$L_2 = 3\,800 \text{ Kgr.-M.}$$
$$L = L_1 + L_2 = 10\,200 \text{ Kgr.-M.}$$
$$= 100\,062 \text{ joules.}$$
$$L = 27.6 \text{ w.-h. per virtual tkm.}$$

Again assuming the coefficient 0.60 for the overall efficiency from the high tension bus bars to the driving wheels, we have :

$$e = \frac{27.6}{0.6} = 46 \text{ w.-h.}$$

The value of σ for the tramway stock is undoubtedly lower than in the case of the railless electric vehicle.

Against the expenditure on tyres there is that for the wear of the metal tyres. On the other hand the interest and sinking fund charges on the rolling stock are rather greater.

An exact calculation is difficult to make.

If we suppose $\sigma = \sigma'$ we rather favour electric railless traction.

The costs of train staff in the case of the tramway, if the load be taken as consisting of one motor vehicle and one trailer, are lower than in the case of the railless electric vehicle service, but as we have supposed $M = M'$ whereas in reality $M > M'$, we can in the same way admit as a rough approximation $p = p'$, although on the contrary $p < p'$.

With these hypotheses we have :

$$\tau'_l = 293\,800 \ \frac{\text{virtual tkm. per annum}}{\text{per km.}}$$

whence :

$$\tau'_l = 816 \ \frac{\text{virtual tkm. per diem}}{\text{km.}}$$

V. — Financial limits to the field of application of railless electric vehicles.

With the hypotheses allowed in the two above calculations the railless electric traction is found to be better than traction by road motor vehicle and tramway where the annual traffic in virtual tkm. is, per km. of line, such that :

$$260\,740 < \tau < 293\,800$$

or in tkm. per day per km.:

$$724 < \tau < 816$$

The limits within which this system is economically applicable are seen to be restricted.

If we examine closely the hypotheses made we find that they are almost all in favour of railless electric traction, such in particular is the case when we supposed $\sigma = \sigma'$.

The hypothesis $a = b$, that is to say the weight of train per passenger taken as equal in the two cases, is the only one unfavourable to the railless vehicle. The use of more exact hypotheses would not modify the results appreciably : we should even narrow the already restricted field of the economical application of railless electric traction.

If we should wish to extend the comparison of the three methods of traction to goods services, we should find that the possibility of applying railless electric traction has completely disappeared and the field of application of road motor vehicles considerably widened as it would be necessary to take into account the advantages of this method in being able to collect and deliver at the customers' premises (7).

Conclusion.

Railless electric traction cannot be economically used for the conveyance of goods traffic. As regards passenger traffic, its field of application is limited and is only possible under certain well defined operating conditions.

Most often the intensity of traffic which would justify from the financial point of view railless electric traction in preference to road motor traction is sufficient to justify the preference being given to electric tramway traction over railless electric traction and over road motor traction.

The practical application of railless electric traction can only be justified in exceptional cases and not from a financial point of view : such as when in the case of heavy urban or suburban traffic, it is desired to substitute for the tram units smaller units as regards the number of seats, running more frequently, and when it is desired to get a road surface better suited to road motor traffic and not spoilt by rails with their unavoidable elastic deformations.

(7) See *Bulletin of the Raiway Congress*, January 1932. « Transportation by railway and by road motor vehicles. »

[621. 33]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

12th SESSION (CAIRO, 1933).

QUESTION V:

Electrification of railways from an economic point of view. Selection of sites for generating stations. Choice of the kind of current. Safety precautions, etc.

REPORT No. 2

(Belgium, Spain, France, Italy, Netherlands, Portugal and their Colonies, Denmark, Finland, Luxemburg, Norway and Sweden),

by Mr. JAPIOT,

Ingénieur en chef adjoint du Matériel et de la Traction, Paris, Lyons and Mediterranean Railway Company,

and Mr. LEBOUCHER,

Ingénieur en chef des Services techniques du Matériel et de la Traction, French Midi Railway Company.

QUESTION I.

The electrification of railways from the financial point of view.

A. — Preamble.

We have wished in the first question to endeavour to find the number, the nature and importance of those factors by which the opportunity of an electrification may be judged, in other words we have wished to attempt to separate and bring to light the conditions that a line or group of lines or a system ought to fulfil if its electrification is to be of value from the financial point of view.

We have considered several types of electrification and endeavoured to classify them according to their general characteristics bringing out the solutions adopted and the results obtained.

B. — General considerations upon electrification.

a) *Economy or suppression of fuel.*

By electrification we understand either the substitution of electric traction for steam traction on the lines where the latter is used, or the use of electric traction on new lines where this method of traction is applied when the lines are first opened to operation.

At the present time, when electrifying a railway, economy of coal is the object sought.

This saving can be effected in two ways : either by using water power when available in the country, or by using the coal in steam power stations.

In the first case the harnessing of the water, the construction of the dams and

the power stations involve costly civil engineering works.

In the second case the erection of the steam power stations also involves the expenditure of large sums of capital.

If the saving of fuel is complete, when the source of energy is of hydraulic origin, it can also be very appreciable in the case of steam power stations.

At the present time, the efficiency of turbo-alternators of high power per unit, the use of fuel of indifferent quality, which could not be used on steam locomotives, where it should be of high quality, make it possible to produce energy much more cheaply than on the steam locomotive.

Compounding, superheating, feed water heating, and special valve gears have without doubt improved the efficiency of the steam locomotive to a considerable extent; if the use of very high pressures has opened new perspectives, it is none the less true that at the present time the steam locomotive remains an instrument of low efficiency.

Thus in certain countries where water power is not available to any extent, the electrification which has been carried out in conjunction with steam power stations especially when these are erected near coal mines, can compete with steam traction in spite of the inevitable losses resulting from the transmission of the power.

In any way and no matter what be the original source of supply of power, the preliminary investigation to arrive at the principal factors which come into account when considering electrification has to be made with care. One of these factors, and one of particular importance, is difficult to determine : this is the weight of coal consumed corresponding to a kilowatt-hour.

The comparisons that have been made on sections formerly operated by steam and now electrified are not many and give rather uncertain values. These results moreover have been taken sometimes from cases of electrification of a rather particular nature and it would be imprudent to use them when considering new lines the characteristics of which may differ considerably.

For example, on the Bordeaux to Irun line of the French Midi Railway, a line with heavy traffic and of easy profile over its larger part, a kilowatt-hour at 1 500 volts at the substation for equal work replaces 2.1 kgr. (4.4 lb.) of coal burnt in the steam locomotives.

It is also necessary to ascertain the number of electric locomotives that must be acquired, in other words to ascertain for an equivalent or more intense service the number of steam locomotives that an electric locomotive can replace. In this case again a comparison with lines already electrified may give valuable figures when there is a great resemblance between the sections in question (profile and traffic).

Without insisting upon the many other factors which must be considered, a balance sheet, which we will deal with in greater detail further on, which takes into account the value of the traffic, the prices of the stock, of the equipment, of labour, the reduction or suppression of coal, makes it possible to ascertain for each line the limiting value of the traffic below which electrification would not be profitable.

At this point, we may say that outside those cases where energy is available at exceptionally favourable prices, it is as well not to count upon obtaining from the electrification of a railway as carried through with the methods now known, large and immediate savings.

b) *Solutions applied to various problems.*

Apart from the possible reduction in expenditure, electrification makes it possible to get satisfactory results in other ways, as it forms an improvement, it betters the efficiency of a railway, and it

often brings an increase of receipts following on the increase of traffic it causes.

It is also capable of bringing a solution to some difficulties that could not be overcome with any other form of traction.

For example, it has made it possible to solve the difficult problem of the blocking up of terminal stations and of the suburban traffic by using block-sets of cars, to increase the weight and the speed of trains, that is to say to increase the capacity of a line and consequently frequently to render doubling of the tracks unnecessary; it has made it possible to work mountain lines in a satisfactory way, and in the tunnels as in the towns to suppress smoke.

Electrification also brings very important economies in labour : staff of the depots, and engaged in handling fuel, enginemen, etc...

Finally in most cases it allows the transmission system set up for feeding the traction lines to be used for transporting and for selling electric energy over the territory of the country.

c) *Technique of electrification. Its future.*

The diversity of the problems arising has been seen. The solutions adopted are not less varied. Actually and from the technical point of view the results are excellent; the public is satisfied, as well as the operator and the staff. The operating results show moreover that the way the work is done is much more important than the system selected.

A few years ago it might have been said that the problem of electrification was a problem technically solved and in its main lines in a definitive way.

This perhaps bound the future rather too much; thus mercury rectifiers have come into use in industrial practice; at the present time they are completely reliable; traction systems use them more and more, as they form a very valuable method of transforming alternating current into direct current. These apparatus have been the subject of constant investigation. Already their use can be considered even on lines where regeneration is used.

What is even better, they will, it appears, make it possible to transport electric energy at a very high tension as direct current with transformation into three-phase current at the point of use.

This would be a complete change in the methods followed at the present time when putting up systems for the transport and application of electric energy. This example shows how necessary it is to be careful when it is a question of expressing a judgment on the state of an art at a given moment and on its possibilities.

C. — The different types of electrification. Examination of the reports received.

After having briefly summarised the complexity of the problems which arise when considering the opportunity of electrifying railways, we will give a brief review of the different electrifications carried out, at the same time endeavouring to classify them by type, and dealing more especially with those about which we have received information.

I. — Electrifications that are necessary.

As we have shown there are certain cases where electrification brings a solution of difficulties impossible of solution with any other method of traction. Even if the benefits of a financial nature are uncertain, or even were they nil, electrification is necessary.

We will now examine such types of electrification.

a) *Suburban and important terminal stations.*

Electrification has made it possible to cover the work in confined stations

in the centres of towns which have become inadequate for the traffic which they have to work.

In many cases, it has made it possible to put off enlarging these stations, the extension of which would have been extremely costly.

A particular instance and a typical one of this type of electrification is supplied by the Gare Saint-Lazare of the French State Railways.

The electrification of the suburban lines of the State Railways, which began in 1900, was not carried out with the desire of using energy produced by water power or by the necessity of working heavy loads over difficult gradients, but by the need for overcoming operating difficulties.

The State Railways have 3 large stations in Paris : Saint-Lazare, Montparnasse and Invalides. The latter was not opened to service until 1900, just at the same time as the first electrified line, that of Paris-Invalides to Versailles-Rive gauche. The result looked for and obtained was to relieve the Saint-Lazare station to some extent.

The difficulties were and still are greatest in the case of this station. They are due to the fact that its equipment no longer answers to the great extension of its traffic. The extent of this increase in traffic may be realised when it is known that the number of passengers leaving this station during the heaviest hour (6.30 p. m. to 7.30 p. m.), which was 13 000 in 1910, today exceeds 50 000.

In 1929, the total number of suburban passengers using the Saint-Lazare station was 106 millions. In the case of the Invalides station it was only 14 600 000 and the Montparnasse 10 300 000.

To meet these difficulties the Railway had to intensify to the maximum the train service at the rush hours. The number of carriages was increased to the limit set by the length of the platforms (i. e. 22 carriages). Nonetheless certain trains worked with a considerable overload of passengers.

On the other hand, the layout of the station made it impossible to alter the composition of the rakes so as to make them suit the number of passengers; these enormous trains ran almost empty at the slack hours of the day and the average use of the seating capacity did not exceed 18 to 20 %. The result obviously was very high traction costs.

In addition to the inadequate number of tracks in the station, there was the difficulty of releasing the locomotives which brought the trains in and the shunting to take water and fuel.

Finally the commercial speed only reached 25 km. (15.5 miles) an hour for the stopping trains and 35 to 45 (21.7 to 28 miles) for the semi-direct trains.

The French Ouest Railway (now included in the State Railways) endeavoured to improve its operation by electrifying its suburban lines.

By this electrification it was possible to use multiple-unit trains. These are trains composed of motor coaches and trailers arranged in such a way that an important rake of stock can be formed of identical elements or sections consisting of a motor coach and one or two trailers; each of these sections includes a driving compartment at each end.

The train is thus formed of one or several of these identical units. The advantages of this arrangement can be appreciated.

As there is a control compartment at both ends the train can run in either direction without any shunting at terminal stations. In this way the difficulties of releasing and coaling and watering the steam locomotives are abolished and thereby the shortage in number of the lines is met.

At the rush hours the train can be formed of several of these sections. But as soon as the number of passengers falls off at the terminus those sections not required are detached and the smaller

train sent away. The sections left behind can be left on the reception roads and be picked up with the greatest ease by a new rake arriving, as the couplings are automatic. If necessary, it is possible to drive them to the holding sidings, as they have their own driving compartments.

In this way it is possible to get an excellent use of the available seating.

Finally the motive power is always proportionnal to the size of the train as it is distributed over its whole length. The same applies to the adhesive weight. These conditions, to which must be added the property of series motors, of developing at starting a high couple, make it possible to start away with certainty and rapidity.

The result of these advantages is the possibility of a higher average speed which pleases the public and increases the operating capacity of the lines throughout. In addition the reception roads are quickly cleared so that the output can be increased.

These were the reasons which led the *French State Railways* to apply electric traction to their suburban lines.

We have moreover mentioned only the principal advantages, those which were sought after to overcome the difficulties which had to be met.

In the same way and in different degrees, several companies have had to solve similar difficulties on their suburban lines or in their terminal stations; thus the Norwegian State Railways, the Nord-Milano Railway, etc., have resorted to electrification.

On this latter system, the Milan-Bovisa section common to all lines radiating out of Milan has the heaviest traffic of express, stopping, goods, and suburban trains. The Nord-Milano Railway first of all considered extending the steam traffic for meeting the traffic difficulties, but it was not possible to install a fourth line on this section which mostly runs between buildings or in tunnels; in addition the Milan station also being surrounded by buildings, the construction of the new lines required for operating at the terminal would have involved insurmountable difficulties.

In this case, once again, the requirements of the surburban service made electric traction by multiple-unit trains essential.

We may also point out that the *Paris-Orleans Company* (P. O.), by electrifying its suburban lines was able to avoid or to put off for a considerable time the sextupling of the lines between Paris and Bretigny, as well as enlarging the Paris stations and certain marshalling yards.

Finally on all these railways, the results obtained have completely fulfilled the hopes and have demonstrated the various advantages of electric operation in such cases.

b) *Elimination of smoke. Metropolitan lines, central stations, tunnels.*

In these different cases and in particular for metropolitan lines the suppression of smoke is absolutely essential; it is not possible to consider any other solution than electric traction. The traffic to be operated moreover imposes it.

The elimination of smoke is also the primary factor in electrifying the lines of large stations in the midst of towns and often also those of the suburban lines ending therein.

This is the reason why the tunnel portion of the Paris-Orleans Company's lines in Paris between the Austerlitz and Quay d'Orsay stations was electrified when first opened in 1900 and why steam traction could not be considered.

c) *Mountain lines.*

The elimination of smoke is also the principal reason for deciding to electrify certain mountain lines where the high percentage of sections in tunnel made it impossible to work by steam or made it

obvious that on a new line it would be difficult if not impossible.

In addition to this reason, the different advantages of electric traction have led the railways to electrify their mountain lines when the traffic seemed to justify it. Again electrification makes it possible, in spite of gradients and curves, to operate the lines satisfactorily. In view of the features of the electric locomotive : power, adhesion, etc., gradients can be allowed which could not be used on steam operated lines; it may be said therefore that to some extent the substructure works may be lessened.

If from the technical point of view satisfactory results may be expected, the economical and financial advantage to be obtained from electrification of this kind are still subject to controversy.

In the case of a new line obviously it is not necessary to take into account steam rolling stock that would have to be used elsewhere, written off, or sold; but it may be argued that it would have been possible to use improved and more powerful steam locomotives which would be capable of operating the railway under satisfactory conditions, and it may be said that the traffic does not justify the electrification where it has not subsequently developed to the extent expected.

As a general rule, however, the electrification of important lines such as those crossing the Alps, or the Pyrenees, like the Ax-les-Thermes to Latour-de-Carol and the Bedous to Canfranc sections with many long gradients, long and frequent tunnels, it would seem ought to be taken in hand.

II. — Electrifications which are excellent propositions.

Such electrifications are those of lines or sections of line where the whole of the conditions required to assure the financial superiority of electric traction over steam traction are found together.

These lines have the whole or some of the following characteristics :

Severe gradients and many of them, long and numerous tunnels, heavy trains, heavy traffic, excessively high cost of fuel, high labour costs, competition of other companies or road services, area with water power, essential increase in the power and speed of the locomotives required.

As may be thought, the number of cases of electrification of this kind is small. They have been carried out with the object of obtaining a commercial profit and this profit is very real.

We will give some examples.

a) *Morocco Railways.*

As early as 1922 the electrification of this system was considered. It had undeniable advantages for various reasons :

Absence of any coal (the price of coal is 30 % higher than in the home country), high cost of European labour, difficulties found in obtaining water for the steam locomotives, long and continuous gradients, high tonnage of cereals, phosphate and ores.

The electrification of the railway was the more desirable as it made it possible to hasten development of the abundent water power of Morocco; it also made it possible to use a high tension distribution system already in existence.

At the present time more than 311 km. (193 miles) of lines are electrified; the results obtained are extremely good. At the present time the completion of a new section of 190 km. (118 miles) is in hand.

b) *North of Spain Railways.*

1. Busdongo-Ujo section.

The principal object sought when electrifying the Pajares bank, the first electrification carried out by the Company, was to relieve the congestion on the Asturias line which connects a mining region of great importance with the centre of Spain. This bank formed a real block.

Before the electrification it was impossible to haul 14 trains daily with two banking engines i. e. 4 250 gross tons. Today it is easily possible to work with one locomotive 20 trains up the gradient, each having the tonnage of those which required two engines when working with steam traction.

By using double heading with the electric locomotives, it is possible therefore to triple the original hauling capacity over the gradient. The block on the transport of coal from the Asturias to the interior formed by the Busdongo-Ujo section has been overcome in this way.

Since this section was equipped, in 1925, no irregularity or congestion has arisen in the service which is worked with perfect regularity.

We would like to point out that during the year 1930, through electric traction, only 219 minutes were lost on the gradient in question, whereas it improved the regularity of working by regaining 112 966 minutes of delays due to the traffic, permanent way, etc., departments.

The speed of the goods and passenger trains has been doubled; an hour has been saved on the time required to work over the bank.

As secondary advantages, we may again quote the abolition of smoke, which caused the service to be particularly trying in the tunnels, the length of which amounts to 60 % of the total length of the journey.

2. Barcelona-Manresa and Barcelona-St. Juan Abadesas Section.

The principal object of electrification in these districts was to improve the outer suburban service so as to recover the traffic lost in the Barcelona-Manresa section.

By 1920, the competition of the Catalonia electric railways was felt particularly severely on the Barcelona to Tarrasa (1922), Monistrol to Montserrat (1923) and San-Vicente to Manresa (1924) sections.

This competition increased through road transport to such an extent that in 1927 the amount lost on the Barcelona-Manresa section was more than a million and a half pesetas as compared with the receipts of the year 1919 when this competition did not exist.

The improvements resulting from electric traction affected especially the frequency and speed of the trains. It was found that there was a considerable increase in the receipts from the passenger traffic in the electrified sections.

For example, the time taken for the Barcelona-Sabadell, Tarrasa-Manresa and Barcelona-Vich sections, the principal centres served are respectively 29, 38, 72 and 94 minutes, with for these last mentioned a gain of 46 minutes as regards the time required when steam traction was used.

The speed for the goods services has also been increased; it has been doubled on certain sections.

On the Barcelona-San Juan line, similar improvements have been introduced in the service; a 20 % increase in the receipts was obtained in 1930 as compared with 1928.

In all the Catalonia regions the regularity of the service has been remarkable. Thus in 1930 only 627 minutes were lost by the locomotives on the Barcelona-Manresa section and 1 034 minutes on the San-Juan line, whereas the electric traction made it possible to recover 111 355 minutes as well as 316 769 minutes of the delays due to other causes.

3. Alsasua-Irun section.

The electrification of this section was pushed forward for two reasons : first of all the increase of the load of the trains and the improvement of the national and international train time tables, and finally the desire to regain and develop the important suburban passenger traffic which from San-Sebastian to the French frontier and vice-versa as far as Zumarraga, was being lost each day by

the North of Spain Company to the many small road transport undertakings.

Through electrification the time between Irun and Alsasua for the express trains of 400 tons (100 tons more than by single-engine steam traffic) 30 minutes was gained. In addition with the frequent motor trains working the Hendaye to San-Sebastian and San-Sebastian-Beasain sections, the time has been reduced both outward and return to 21 minutes and 68 minutes, that is a respective gain of 10 and 40 minutes on the old timetables.

As on the other sections the regularity of working has been remarkable.

c) *Algerian State Railways.*

The electrification of the Duvivier to Oued-Kéberit section was necessary for the following reasons :

The existing track and rolling stock were insufficient to carry the expected mineral traffic, which includes for example the carrying to Bône of 4 500 000 tons per annum of iron ore and phosphates.

Heavy trains hauled by steam would have had to be divided when running over the difficult sections. This would have caused many inconveniences : it would have meant a large number of train movements over the difficult sections and consequently a too long period of occupation of these sections.

Moreover the number of train-kilometres would have been very great in respect to the useful train-kilometres; finally this dividing up would have involved a complicated series of shunts.

Moreover tests made hauling part trains with three engines showed that it was impossible to work through two tunnels 643 and 550 m. (2 110 and 1 800 feet) long near Souk-Ahras on a gradient of 1 in 40 and with curves and reverse curves of 250 m. (12 1/2 chains) radius, without serious danger to the men. It was moreover impossible to divide up the trains further.

These were the reasons why electric traction was adopted on this section of the Algerian State Railways.

III. — Electrification of the main line Companies.

The examples we have given show how delicate it sometimes is to judge the advisability of electrifying railways outside certain well defined cases; it will be realised that many private companies although aware of the advantages that they would gain from electrifying part or all their system hesitate owing to the large capital expenditure involved, especially when the drawbacks of steam traction are not such as to render electrification urgently necessary and when the financial results to be obtained from the change over appear to be rather problematical.

The electrifications about which we would speak are those of the main line companies, which could be operated for some time to come by steam traction without inconvenience.

Many of the electrifications of this kind have been undertaken either by the State Railways or at the instigation of the State. They have been given the name of *national* in the sense that the State may encourage them for reasons of public economy, to reduce or suppress the importation of fuel, develop the water ressources of the country, employ labour, create or facilitate the development of the home industry, whilst improving the efficiency of the railways.

In France, the changes subsequent to the war called attention to the desirability of using the available water power. A second problem arose, that of selecting or rather of standardising the method of traction.

A Commission nominated for this purpose by the Government drew up, after careful enquiry, a report in favour of

the direct current system at 1 500 volts and this system was made obligatory by a Ministerial decree of the 29 August 1920, it being understood moreover that the tension could be increased to 3 000 volts in certain particular cases.

At the same time, at the invitation of the Government, three of the main line railways, the Midi, Paris-Lyons-Mediterranean (P. L. M.) and Paris-Orleans prepared a programme of electrification affecting more than 8 000 km. (5 000 miles).

It will be appreciated how delicate a matter it is to select a system of electrification either for a railway system or for a group of systems especially when several electrifications of parts of systems had already been carried out with different systems or types of current.

Thus, the *Midi Railway* commenced before the war to carry out a programme of electrification using single-phase current and found itself, as a result of the decision which we have mentioned, obliged to do the work almost entirely over again, in order to equip its lines for direct current working.

As would be expected the French Companies commenced to carry out their programme of electrification by first of all equipping those of their lines which appeared likely to show some financial saving and which appeared likely to give results of this kind, if not immediate and certain, at least probable in the future.

For these reasons the Midi Company fitted up certain of its lines with heavy traffic, such as the lines from Bordeaux to Irun, Toulouse to Dax and branches, etc.

This Company had had in mind for a long time the electrification of its system owing to the considerable water ressources that it could use in the Pyrenees. Their extent made it possible to think that the power stations would be able to supply, in addition to the power required to work the trains, a large excess of current. These hopes have been realised. We will examine further on the results obtained.

The electrification of the Paris-Orleans Railway was originally considered (1917-1919) as the only possible solution of the problem of the supply of fuel which at that time was particularly difficult for the whole of the railways owing to the state of war. Actually the decision to carry out the first section of the electrification programme which had been prepared at that period was taken almost exclusively with the two following objects in view :

1. Reduction of the import of coal, the cost of which had become excessive;

2. The use of the water power of the « Massif Central », then unexploited.

For these reasons the first section of the work dealt with the Paris-Brive line, one of the most heavily loaded of the system, and at the same time that which geographically was the best placed for being supplied in power from water stations from the « Massif Central ». In this way the transmission of high tension supply for feeding the traction substations could at the same time be used to connect the producing area of the Massif Central to the very important consuming centre of the Paris area.

No doubt many other advantages were also used as arguments in favour of electrification.

The continual increase in wages during the after-war period and the difficulties in the way of recruiting staff for handling the locomotives as well as the staff in the depots impelled the company to endeavour to effect a saving in labour which only electrification made possible.

As we have already pointed out the increase of the passenger traffic in the Paris suburbs would have made it necessary, with steam traction, to purchase many locomotives as well as to do considerable work in the way of providing lines and increasing the size of the sta-

tions, which electrification by the increase in speed and the weight of the trains rendered unnecessary.

The P. L. M. Company having decided to electrify as an experiment one of the important lines of its system selected the Chambéry to Modane line because it should be possible to carry out such experiments under very varied conditions owing to its easy section at the start and subsequently to the long gradients continually increasing in steepness up to 1 in 33 over the last 15 km. (9.3 miles). As the international express trains run over this line it lent itself to traction tests at high speed over the easy section. On the other hand the last section made it possible to study electric traction on mountain lines with regeneration on the down trip. In addition an abundance of energy from hydro-electric stations was at hand. Finally owing to the importance of the through Franco-Italian traffic and the heavy costs of traction over the upper part of the line owing to the gradients and the bad quality of the water, electrification should provide valuable savings. Experience has entirely justified these previsions.

* * *

Apart from France we will mention two important systems, the *Swedish State Railways* which have more than 900 km. (560 miles) of electrified lines and the *Italian State Railways.*

The Italian Railways considered the question of electrification as early as 1897 and the installation of the Valtelina line, opened in 1901, enabled them to investigate from the practical point of view the different questions raised by the 3-phase system and to appreciate the advantages which electric traction could procure in Italy, a country rich in water falls and where the operation of certain lines, owing to the gradients and tunnels, is very difficult.

The electrification of the lines in the neighbourhood of Genoa and particularly that of Giovi, with heavy gradients and heavy traffic, gave remarkable results. The speed and the weight of the trains were doubled and their number increased, and from this fact the capacity of the line was practically increased tenfold. The total operating costs were reduced by 22.5 % in comparison with the costs of steam traction.

This increase in output made it possible in the case of certain lines (Cenisio, Porrettana, etc.) to put off for a long time the doubling of the track and even the construction of a new line (Genoa-Milan).

The war showed the difficulties that can arise, in a country such as Italy, through the almost complete absence of coal mines.

Consequently, by 1919 the problem was examined from a more general point of view and the advantages that electrification might have, not in some few cases and on special points, but on a much wider scale, were investigated. The extremely high prices of coal (nearly 12 times that of pre-war) and especially the considerable difficulties found in obtaining it called attention to the advisability of using for traction purpose in the greatest possible measure the available water power.

At the present time, more than 1 800 km. (1 120 miles) are electrified and the quantity of coal, that has been saved by electric traction amounts to about 650 000 tons a year, that is nearly a quarter of the consumption of the steam locomotives; it represents a value of 90 000 000 lire.

The part of the system electrified with three-phase current (16 2/3 periods), by its extent, and the traffic which it carries (80 % of the traffic of the electrified lines), can give particularly convincing operating results. This zone includes most of the crossings of the Alps and Appennines and has gradients of 1 in 62 to 1 in 38 with a maximum of 1 in 28. Its very special characteristics are such

that it is diiffcult to find on the steam worked system any lines allowing a rigorous technical and financial comparison to be made. Furthermore, any comparison of the financial results of working certain sections before and after the introduction of electric traction has shown itself to be difficult and uncertain.

The comparison of the same elements for the wider areas is also altered by the considerable variations in the prices of the materials, of labour and of the traffic conditions since the end of the war up to the present time.

The Italian Railways consider however that owing to better use being made of its existing installations the advantages amplify themselves as the electrified system is extended. These advantages remain even if the electrified system were to absorb the sections of secondary lines the electric operation of which would be of little value if they were situated in other areas.

The advantage of electric traction shows itself particularly favourable when the traffic increases.

The most recent and most typical example is given by the Florence to Bologna (Porrettana) line, where electrification has made it possible to increase by more than 5 % the capacity of the line which was saturated when operated by steam.

Outside certain well recognised technical advantages the Italian Railways consider that the operating costs, including the capital charges on the electrified system, reduced to the virtual ton-kilometre hauled, do not sensibly differ from similar costs on the system worked by steam. The available figures are not however either uniform or comparable owing to the very dissimilar characteristics. The electrified system using three-phase low-frequency current includes important mountain lines with heavy gradients over which it is quite certain that steam operation would be under most unfavourable conditions, whereas electric traction in such cases finds the conditions of use, wherein its superiority, even from the financial point of view, is revealed.

If it were possible to establish a comparison between the costs of electric traction and those of steam traction on the same lines and under identical conditions, the results would very certainly be favourable to electric traction owing to the high percentage of mountain lines included in the Italian railway system as a whole.

This railway system considers that in view of the present price of coal and the cost of the fixed installations, the economies alone that electric operation procures are sufficient to encourage its wider application. On the other hand, in the case of lines on which there are no heavy gradients, it considers that the balance is most uncertain, unless it be founded upon theories of intensity of the traffic which do not appear to be justified either by the present state of transports nor by the competition of various other methods of transport.

The reasons in favour of a vast extension of the electrification of important lines cannot in consequence be founded upon a financial comparison between the operating costs alone but much rather on a consideration of the indirect advantages which vary from one country to another.

The electrification of the railways is in the case of Italy a vital problem because it guarantees the independence of a service of particular importance for the defence and the economic life of the country.

In addition it contributes to the development of all available sources of water power and facilitates the interconnexion of the main power transmission systems.

Finally the Italian Railways do not consider that the market price of coal is invariable and think that at the time of preparing a balance-sheet for an elec-

trification the possibilities of a political and economic nature, both local and international, may completely upset the bases of this balance-sheet and result in economies which in a relatively short period can make it possible to wipe out the capital cost of the installation.

The electrification of the railways tends therefore to create a potential richness, the contrary to what occurs with steam traction.

A series of lines or even of systems as important as those we have examined obviously includes lines of very different kinds, but whether it is a question of lines the electrification of which appears at first view as a successful operation from the technical point of view and profitable from the economic point of view, or of lines the equipment of which does not seem to be so evident in value, it is desirable to prepare a very careful balance-sheet of the proposed conversion.

This balance-sheet brings out the annual expenditure that is required by the two methods of traction. Let us briefly show the principal headings which may be introduced in it.

I. — *Traction energy.* — On the one hand the consumption of coal; on the other the number of kilowatt-hours.

II. — *Lubrication of the locomotives.*

III. — *Upkeep of the locomotors.*

IV. — *Locomotive staff.*

V. — *Water supply.*

VI. — *Staff and various expenditure at the depot.*

VII. — *Supervision and maintenance of the fixed electric installations.*

VIII. — *Annual capital charges of the new installations.*

IX. — *Annual charges of the locomotive-capital.*

In examining chapters VII and VIII, as regards electric traction it is desirable to take into account the work in connexion with the rail bonding, the modifications of the stations and structures and displacements of the telephone and telegraph lines. It is also necessary to take into account the installation on the carriages and brake vans of electric heating.

Finally under chapter IX it is necessary to consider on the one hand the effective capital cost of the steam locomotives used on the line, and on the other hand the capital charges for purchasing the electric locomotives and the capital charges for steam locomotives no longer of use through the electrification.

In a balance-sheet which we recently prepared for the preliminary project for the electrification of a line, the capital charges (VIII and IX) represent about 55 % of the total annual charges.

This at once shows how important a role these charges play and, for the same reason, that of the rate of interest on any loan a railway system may be obliged to contract.

For example, let us consider the results obtained by the French Midi Railway Company :

In 1930 the train-kilometre cost 10.85 fr. (17.46 fr. per train-mile) with steam traction as compared with 6.655 (10.71 per train-mile) with electric traction.

These costs include all the general charges of the rolling stock and locomotive running department, the maintenance of the carriages and wagons distributed uniformly over the two methods of traction, but do not include the costs of operating and of track maintenance.

As regards steam traction they include the whole of the expenditure due to this method of traction, staff, fuel, water, maintenance and repairs of the locomotors.

In the case of electric traction they take into account the whole of the operating costs, repairs and maintenance, staff of the works, high and medium ten-

sion lines, overhead lines, transformer stations, substations, locomotives, etc., but do not include charges on the capital invested.

The rate of interest on the loans, interest and amortisation on the money required for the electrification has varied widely during the period in which the work was carried out; it rose from 5.25% in 1913, to 6.88 % in 1919, and reached 14.6 % in 1926.

A rate of this kind made impossible all continuation of the work which had been considerably slowed down and even held up at that period. The same observation can moreover be made as regards the Paris-Orleans Company.

In 1927 the rate of interest and amortisation fell again to 10.86 %; subsequently it has continued to fall and became 7.93 % in 1928, then 7.2 % in 1929 and 6.25 % in 1930. This reduction made it possible for the company to again take in hand its electrification work.

We see then that if investigation into the characteristics of a line or group of lines and the comparison with the results obtained on other similar sections make it possible to judge of the advisability of electrification, there is an essential factor to be considered in the preliminary enquires, and that is the rate of interest to be paid for the money.

D. — Conclusion.

During this brief review of the financial side of the electrification of railways we have endeavoured to show by several examples that electrification becomes the more essential as the traffic increases, coal and labour become dearer, and the electric energy cheaper.

As a matter of fact there is no formula by which it is possible to say in each case whether it is desirable or not to electrify; it is necessary to select a line or a system which has been electrified, which has the greatest similarity with the line considered and then to carefully scrutinise the results of working it and therefrom to prepare a balance-sheet.

We have seen the importance of the rate of interest; this is to say that the financial situation and the state of the money market play a capital role in the development of electrification.

It may even be asked if a general severe and lasting financal crisis is not capable through the modification it makes in certain factors of introducing elements favouring the carrying out of important works such as the electrification of the railways.

In fact financial crises are characterised by unemployment, the superabundance of manufactued goods, the low price of raw materials and the fall of the shares of varying returns.

This would be, it would appear, the moment to use unemployed labour, to purchase raw and partly manufactured materials and to offer to a public tired of shares with high and uncertain returns a loan with an undoubtedly lower rate of interest but better guaranteed.

QUESTION I.

Résumé to serve as a basis for the discussions at the Congress.

A. — *Preamble.*

B. — *General considerations on electrification.*

a) Two solutions : steam power stations, water power stations, the limited possibilities of the steam locomotive;

The various factors which come into play when considering the advisability of electrification :

Weight of coal burnt equivalent to a kilowatt-hour;

Number of steam locomotives replaced by an electric locomotive;

Necessity of having power at low prices.

b) Satisfactory results to be expected from electrification outside the economic one, traffic, labour, etc.

c) Importance of carrying out the work well;

Future technical progress. Mercury rectifiers.

C. — *The different types of electrification.*

I. — *Electrifications that are required.*

Difficulties to overcome. — Possible financial advantages.

a) Suburbs and large terminal stations. — French State System. — Nord-Milano System.

b) Elimination of smoke. — Metropolitan railways, central stations, tunnels.

c) Mountain lines. — Trans-Pyrenean lines.

II. — *Electrifications which are excellent propositions.*

Lines where all the conditions required to get good financial results are found.

a) Morocco Railways. — Ore and phosphate traffic.

b) North of Spain Railways. — Mineral traffic.

c) Algerian lines of the State Railways. — Mineral and phosphate traffic.

III. — *Electrification of large railways.*

Amount of capital involved. — Certain systems can be operated for a long time to come with steam. Economies to be realised.

Electrifications known as « National ».

Importance of the problem of the standardisation of the systems of electrification and of the type of current in a country.

Examples : French Midi. Paris-Orleans. Paris - Lyons - Mediterranean. Swedish State. Italian State.

Investigation into the lines there is a financial interest in electrifying.

Preparation of the balance-sheet.

Importance of the rate of interest on the capital.

D. — *Conclusions.*

Outside the characteristics of the lines to be investigated the importance of the role played by the financial situation and the state of the money market.

QUESTION II.

Location of generating stations.

When a railway considers the electrification of a line or a group of lines, several solutions may be considered for the supply of the current required; the railway system can produce the current itself in stations which it will have to build, or it may purchase it from a supply company, or it may finally do both.

I. — Power stations belonging to the railway.

The railway system builds either steam stations, or water power stations. In the two cases the capital that has to be devoted to this purpose increases very considerably the annual interest charges.

On the other hand the production of power and its transmission are under the direct control of the railway; it can therefore so arrange that these two operations take place under the most favourable financial conditions possible.

Whether it is a question of energy from a steam plant or from a hydro-electric plant, while not neglecting to provide for the requirements of the future, it can also take care not to limit itself to building power stations strictly limited to its needs. It can consider the production of energy above its requirements, and its transport and sale.

The high tension lines that the railway

is obliged to build for the transmission up to the principal feed points of the current required for traction purposes are in this way used to their maximum; it can even be said that this extra transmission required will not generally involve a marked increase in the costs of constructing the power lines. Should such increase be necessary, however, it could still be arranged under the same title as the increase of the power of the station if the outlets justify it. The interest a public service of such vital importance as the railway has in assuring in the largest possible measure the regularity of running of its trains can be appreciated; consequently the question of reserves has been given special attention by the railways.

Two points of view have moreover to be considered :

Reserve supply in the case of failure, or shut down; reserve to make good any momentary shortage of power at the generating stations. In the first case it may be necessary to build steam standby stations.

The large power capacity they must have and the large amounts of capital that must be locked up will be appreciated.

Another solution consits in providing for these power stations to be used to supply the peak loads and to design them in consequence.

Although most of the reports received have only given on these different points none too definite replies, it does not seem that these different solutions have been adopted in many instances. In the case of breakdowns or accidents in their power stations, the railway systems have, in general, fallen back on neighbouring distributors of energy, to which they have arranged to be connected and with which they have entered into suitable contracts.

Although the spare supply of energy may be charged usually at a high rate because it may be required at any moment by the railway system, this remains at the present time the most usual method and that best justified.

In the second case, the railway system has at its disposal supplies of energy which, while enabling it to operate satisfactorily in normal times, can at certain times become insufficient.

Such is the case of a railway system drawing its energy from water power stations and which needs additional supplies at certain periods of the year. In the absence of engineering works judiciously and largely conceived or of pumping stations to recover water from certain tributaires with surplus supplies of water at the times needed, the railway system finds itself obliged to be connected with the neighbouring power distribution systems.

The production of energy can then be regulated by the linking up of power stations having different characteristics, whether it is a question of water stations under varying hydrographical conditions (snowfalls, rain, etc.) and using watersheds in which the periods of low level do not coincide, or with steam stations that can be utilised to give the additional power during such periods.

The regulation of the consumption can deal not only with the daily variations, but with the annual variations of consumption owing to the needs of areas under different traffic conditions : industrial districts, agricultural areas, etc.

Finally, when the nature of the current and its periodicity allow it, it is possible to operate the system in parallel with the neigbouring distributing systems and to feed into these systems any temporary excess of current from the railway system.

The satisfactory results that this linking up of the power stations and interconnexion of the transmission systems will have will be appreciated immediately.

The Paris-Orleans and the French Midi Companies have made use of these methods when arranging for their supplies of energy.

The energy used by the French Midi Company is entirely produced by water power in stations belonging to the company, all of which are situated in the Pyrenees.

In addition to two small isolated stations in the eastern Pyrenees the Midi Company operates at the present time 5 large hydro-electric stations of a total installed power of 130 000 kw. the stations having very large regulating reservoirs and producing annually about 340 000 000 kw.-h. of which 160 000 000 are used by the railway.

This energy is transmitted to the using points by a system of transmission lines including :

1. A main feeder of 150 000 volts running the whole length of the central Pyrenees and extended in double line to Bordeaux, and in single line as far as St. Victor near Millau.

2. A system of 60 000-volt lines running alongside most of the electrified railways and supplying the traction substations.

These two systems are connected together at 6 large transforming stations of 150 000/60 000 volts.

Provision was made from the beginning for the whole of the installations to be used, in addition to the railway's own requirements, for transporting energy for other producers or users.

The whole of the important hydro-electric stations in the central and western Pyrenees are today linked up with the transmission lines of the Midi Company, these lines being used to feed the consuming centres where are their customers.

In order that the whole of this arrangement should work properly and at the same time resolve the delicate problems, both technical and commercial, which arise, an organisation has been set up which regulates and distributes the power produced; this organisation is known as the « Union des Producteurs d'Electricité des Pyrénées Occidentales » and acts at the same time as a selling agency.

This union includes all the large energy producing undertakings using the transmission lines of the Midi Company, whether in the Pyrenees or in the « Massif Central ».

The number of members is 11, operating 28 generating stations, the total installed power of which amounts to 380 000 kva. producing annually more than one billion kw.-h.

In addition agreements concluded with certain steam power stations also linked up with the transmission lines of the Midi Company enable it to rely on reserve supplies of power or to regulate the supply.

Finally these lines have to be extended in the near future in agreement with the « Union des Producteurs » towards the Marèges station on the one hand and towards the Rhône valley on the other, so as to link up the transmission system of the Midi with that of the Paris-Orleans and with the power stations in the Alps, in this way providing a complete linking up between the three main French regions producing hydro-electric power.

II. — Stations not belonging to the railway.

Certain companies have not built generating stations and have arranged for their system to be fed from distributing centres.

A number of railways have been led to adopt this solution because of the facilities that it gives in many cases : trials of electric traction on a small scale requiring little power, proximity of existing power stations or transforming stations not requiring more than short feeder lines or even making it un-

necessary to build such lines, and finally cheap power when the section to be electrified is situated in a region where the water power resources are good.

Undoubtedly this is the method for considerably lightening, at the moment of electrifying a line, the expenditure involved. But if the concentration in very large power stations of the production of power for all purposes including traction facilitates proper utilisation of the power, the fact still remains that the railway, a public service the importance of which we have already underlined, in this case depends upon private undertakings over which it has no control.

It is desirable therefore in this case to obtain very special guarantees as to the regularity of supply when making the contracts.

In spite of the difficulties which may be expected from this method of obtaining power, many railways have used it.

Such are: the French State, P. L. M., Morocco, North of Spain, Netherlands, and Dutch East Indies Railways.

III. — Combined system.

In this group we may mention the Paris-Orleans Company.

This company has built up its electrification on the combined use of hydro-electric power produced in its own generating stations or with its financial help in the « Massif Central », and power produced in the steam power stations in the Paris area, of the « Union d'Electricité ».

The first group of power stations include at the present time the Eguzon station on the river Creuze (50 000 kw.) built by the « Union Hydro-Electrique », a company in which the Paris-Orleans Railway is interested, and that of Coindre on the river Rhue (24 000 kw.) built by the Paris-Orleans Company itself. Two other stations are under construction at Marèges and La Cellette.

The second group of stations are the Gennevilliers and Vitry power stations, with a total power of about 400 000 kw.; these power stations are linked together by the feeder lines of the Paris-Orleans Company, which consist of a double 90 000-volt line from Eguzon to Paris which supplies the traction substations between Vierzon and Paris, and a single 150 000-volt line connecting Marèges (near the Coindre station) to that of Chaingy near Orleans. This latter line is being extended to Paris and its voltage will be increased to 220 000. These two systems of transmission lines are connected at the transformer stations of Eguzon, Chaingy, and Chevilly near Paris.

These lines are not intended to meet the needs of the railway alone. They have to be connected to a certain number of local distribution sections en route. Moreover, the large Marèges station from which the 220 000-volt line starts should be connected to other power stations of the « Massif Central », especially those of the Haute-Dordogne, La Cère and La Truyère.

We may add that this 220 000-volt line will be doubled by a similar line. These conjugated lines will form a powerful feeder with a capacity of about 200 000 kw. and make it possible with the maximum of safety to get interconnexion between the steam stations and consuming centre of the Paris area on the one hand, and the power stations of the « Massif Central » on the other.

The Italian State Railways have also used the combined system for feeding their traction system.

We will deal especially with the railway system equipped with three-phase current at 3 700 volts, 16 2/3 cycles, which is the most important.

This system is fed by:

1. The water power stations at 16 cycles, in the Alps and the Apennines;

2. Substations near the railway and converting the industrial frequency re-

ceived from far distant stations into 16-cycle current;

3. By 3 steam stations which act as standby and also supply energy required for seasonal traffic, and especially during the winter.

Out of 13 power generating plants or stations at which the frequency is changed, there are two hydro-electric stations properly speaking and 2 stations belonging to the State Railways.

Out of the 3 steam stations (located at Genoa, Savona and Livorno), of a total installed power of 30 000 kw. one, that of Chiapella (Genoa) belongs to the State Railways.

All the other power stations belong to different private companies.

66 % of the energy consumed by electric traction is bought from these companies, part at 16 2/3 cycles, and part at industrial frequency.

The system electrified with three phase current at 3 700 volts, 16 2/3 cycles (power installed: 185 000 kw.) consumes 80 % of the total power used for hauling the trains. This energy is almost entirely produced in water power stations (97 %); the rest is generated in steam stations.

Thanks to the primary interconnecting lines, the regulation is obtained either by steam power stations, or by the water power stations in the Apennines, or by stations converting the industrial frequency current stored up in the Alpine reservoirs of the private companies.

At the present time, the daily summer production of three-phase current, 16 2/3 cycles, of the power stations in the Alps represents 70 % of the energy consumed for electric traction; in winter it only reaches 30 % of this same energy.

In fact, thanks to the linking up of the water power stations and steam power stations with the stations converting the frequency, not only is the regularity of working assured under good conditions but the power available is almost completely used.

IV. — Conclusion.

From the rapid examination that we have just made it would seem that there is a tendency to interconnect the supply systems between one another, in order to assure to the fullest possible extent the regularity and the continuity of the supply of power.

As regards the solutions adopted, it can be seen how varied they are; they appear, in fact, to have been imposed very often by circumstances rather than by principles.

QUESTION 2.

Résumé on which to base the discussions at the Congress.

Three solutions offer themselves for feeding a traction system:

I. — Power stations belonging to the railway.

II. — Power stations not belonging to the railway.

III. — Combined system.

I. — *Power stations belonging to the railway.*

Advantages for the railway in possessing its own power stations, and in selling the excess energy.

The reserve supplies :

1. Shut downs and breakdowns;
2. Shortage of power.

1. Steam standby stations. — Power available. — Obtaining assistance from nearby supply systems.

2. Connection with the supply systems. — Value of this as regards regulation of power supplies.

Example of the French Midi Company. High tension system. Interconnexion.

II. — *Power stations not belonging to the railway.*

Reduction in capital expenditure when electrifying.

Against this : dependence of the railway on the supplying companies.

Examples.

III. — *Combined solution.*

Example of the Paris-Orleans Railway.

Interconnexions.

Italian State Railways.

IV. — *Conclusion.*

Tendency towards general linking up. — The solutions seem to be more frequently imposed by circumstances than by principles.

QUESTION 3.

Choice of the type of current.

A. *General review.*

Most of the railways to which our report relates use for traction purposes *direct current* at different voltages : 650 volts on the French State, 1 500 volts on the Midi, Paris-Orleans and Paris-Lyons-Mediterranean, North of Spain (except the Pajares line), Netherlands Railways and Dutch East Indies Railways, 3 000 volts on the Algerian State Railways, the Morocco Railways, the Pajares Line (North of Spain) and the Nord-Milano.

On the other hand the Swedish and the Norwegian State Railways use *single-phase current at low frequency* (15 or 16 2/3 cycles per second, and 15 000 or 16 000 volts).

The Italian State Railways after having developed in all the northern part of their system the use of *three-phase current at low frequency* (16 2/3 cycles per second, and 3 700 volts) have recently made trials with *three-phase current at industrial frequency* (45 cycles per second and 10 000 volts and have finally selected *direct current* at 3 000 volts for the electrification of lines outside the zone reserved to three-phase low frequency current for traction purposes.

It is important to note, however, that this diversity of solutions is only met with on railways which electrified their lines before the war : *all the administrations who have only tackled this problem since the last ten or fifteen years have uniformly selected direct current.*

It may be objected that this is too positive a statement seeing that the electrification of the Ofot line by the Norwegian State Railways with monophase current at low frequency only dates from about ten years, but this operation in fact only formed an extension into Norwegian territory of the electrification of the Swedish Lapland line, where this system had been in use for some time. The unanimous decision in favour of direct current consequently remains the dominant feature of recent decisions, when the selection of the type of current is not already governed by certain special considerations.

We propose consequently to examine first of all the reasons which formerly caused various solutions to present themselves and then show the considerations which have recently favoured the general adoption of direct current in new cases of electrification.

We will see in particular that the variety of the early solutions is due to *technical development* in the different periods when the problem was dealt with by the various administrations, — whereas the unanimous opinion in favour of direct current seems to be much less due to technical progress itself than to *the new aspect under which the electrification of railways is now considered.*

B. — *Early electrification: Direct current at low tension.*

The first applications of electric traction on the great railway companies con-

sidered in the present report date back to the end of the 19th century or the beginning of the 20th.

At that period there was only one system of electric traction sufficiently perfected to lend itself practically to immediate application: that was *direct current* at a tension of about 600 volts, the current being picked up from a conductor rail called the « third rail ». This is the reason why this system was adopted for example in 1897 for the Paris-Orleans Company when electrifying its lines inside Paris, and later in the neighbouring suburbs, — in 1900 by the French Ouest on the Paris (Invalides) to Versailles line, subsequently incorporated in the State Railways, — in 1901 by the Paris-Lyons-Mediterranean Company on the Chamonix line, — in 1901 also on the Italian line from Milan to Varese, — and in 1902 by the Midi Company on the line from Villefranche to Bourg-Madame, — etc.

In all these applications only *lines of rather short length,* run over by *frequent and relatively light trains,* were in question; the low tension direct current lends itself perfectly to the economical operation of lines of this kind, as is shown by the favour it still enjoys when the electrification of city and suburban lines is under consideration.

On the other hand, it was thought from the beginning that this voltage was not high enough to make it possible to extend its application under acceptable financial conditions, to the electrification of lines of great length, run over by heavy but relatively infrequent trains. It was therefore considered essential for such lines to turn to *appreciably higher voltages,* as much to reduce the cost of installation as to make it possible to use powerful locomotives.

C. — *Low frequency three-phase system.*

It was under these conditions that the problem presented itself in Italy, as early as 1897, and was tackled with the desire of using on the contact line a tension of about 3 000 volts, then incompatible with the use of direct current.

Monophase electric motor design was then only at the experimental stage, whereas the three phase induction motor seemed to be the ideal traction motor owing to its strength, its simplicity due to the absence of commutators, and the possibility of using the high tension proposed on the contact line direct. For these reasons preference was given to the *three-phase system.*

The *frequency* then had to be decided. The use of gears not being considered desirable at that period for the high powers in view, it was thought better to drive the wheels from the motors either directly or through rods. Consequently owing to the low speed of rotation thereby imposed on the motors, the construction requirements, electrical as well as mechanical, led to the adoption of rather a low frequency first of all fixed at 15, and then at 16 2/3 cycles per second.

We all know the subsequent marvellous development of the three-phase low frequency system on all the important lines on the northern part of the *Italian State Railways,* — and notably to what a state of perfection the engineers of this railway have progressively brought the three-phase locomotives, which are among the lightest having regard to their power.

D. — *Low frequency single-phase system.*

The desire to avoid on the one hand the complication of the double contact line of the three phase system, and on the other to use voltages appreciably higher than that of the 3 700 volts adopted in Italy, subsequently led other railways to profit by the technical progress that had been made to select *single-phase current.*

Owing to the simplicity of its contact line, and to the use of voltages of the order of 15 000, making it possible to spread the substations farther apart, the single-phase system should in fact result in appreciable economies on the cost of installation, — savings capable of balancing, and leaving a margin, the increased cost of expenditure for the purchase and maintenance of the more complicated locomotives. In addition in spite of the progress realised with time in the construction of the three-phase locomotive, as regards the regulation of the running speed, the great range which the single-phase locomotives showed in this respect was an important advantage in working the main lines. As in the case of the three-phase current, however, the use of a rather low frequency was still necessary but only for reasons inherent to the construction of the motors themselves.

The advantages of single-phase traction having been shown by the tests carried out on various railways, the Netherlands Railways decided to adopt this system, using 10 000 volts, 25 cycles per second, when electrifying the line from Rotterdam to La Haye, which was carried out in 1908. On the other hand the French Midi arrived at the same conclusion and took in hand in 1912 the electrification of certain lines in the Pyrenees with single-phase current at 12 000 volts and at a frequency of 16 2/3 periods per second. Towards the same period the Swedish State Railways selected 15 000-volt, 15-cycle single-phase current when electrifying its Lapland line, and the Norwegian State Railways quite naturally selected the same current when it subsequently undertook the electrification of the Olof line, an extension of the Lapland line into Norwegian territory. Subsequently these two railway systems continued to use the single-phase, 16 2/3-cycle system on their later electrifications.

E. — *General characteristics as regards the choice of current of electrifications carried out before the war.*

During the period between the last years of the 19th century and the war, each case of electrification of a railway was considered as an *isolated problem*, and care was taken to arrive, in each case, at the *particular solution* which then seemed the most suitable.

At this period, the application of electric traction on a main line railway formed in fact an operation sufficiently delicate in itself that care was taken to avoid bringing in any consideration foreign to the technical problem thus set.

An endeavour was made to find the most satisfactory solution the then technical knowledge could procure and it was to the successive stages of this development that the diversity of the solutions adopted is due, and especially the use of low frequency alternating currents, first of all three-phase and subsequently single-phase.

The use for electric traction of low frequency alternating current, practically unusable for other purposes, did not then show any of the drawbacks that subsequently revealed themselves.

On the one hand, the generating stations then existing were not as a rule sufficiently powerful, nor their high tension distributing systems well enough organised to guarantee for electric traction on a main line railway sufficient security of operation; each electrification was therefore obliged to have its own plants for producing and transmitting the energy it required.

Moreover, except perhaps in certain particular cases, the development of undertakings distributing electric energy was then too limited for the advisability of linking up the power stations and the high tension systems to show itself.

The use of different frequencies for traction purposes and for the distribut-

ing companies then fitted in perfectly well with the idea of separate stations and independent transmission lines.

F. — *Evolution of thought on electrification and its reaction on the selection of the traction current: adoption of direct current.*

It is only during the last fifteen years or so that the question has completely evoluated in an opposite direction, and that broad views have prevailed so as to bring the electrification of the railways into the scheme of the general electrification of a country.

It has been recognised that in order to *reduce the cost price of electric energy,* as well for traction as for all other purposes, it was indispensable to make arrangements for a *large linking up* of the generating stations, and to push on as far as possible the use in common of the high tension transmission lines. A rational and economical solution of this problem could only be obtained by the *standardisation of the type and frequency of the primary current,* which should translate itself into the uniform adoption as primary current of *three-phase current at industrial frequency.*

However great might have been the development of electric traction on the great railways, the consumption of power for this purpose could never represent more than a rather small fraction of the total consumption of a country. Experience has moreover proved how well founded this way of looking at the question was: thus in *France,* out of a total consumption of 12 000 000 000 kilowatt-hours in 1929, the great railway companies only consumed for electric traction purposes 315 000 000 kw.-h., that is about 2.6 %; in *Italy* where the electrification of the railways has been developed for a longer time, the proportion only reached 3.5 % for the same year 1929 (347 000 000 kilowatt-hours out of a total production of about 10 000 000 000).

The standardisation of the frequency on the primary distributing systems implies consequently the practical abandonment of low frequency alternating current, if not on the contact lines themselves, at least for *feeding the traction substations.* Consequently the problem of the choice of current presented itself under a quite different aspect.

It was no longer a question, as in the past, of deciding in each case the type of current by which the most economical installations for the railway could be got and the most perfected in itself as regards the technical aspect, — but solely to adopt the system *capable of fitting in, in the best possible way, the financial and technical desiderata with the obligatory feeding of the substations with three-phase current at industrial frequency.*

Progress realised meantime in the construction of *direct current generators* and motors for *sensibly higher voltages than those previously used,* made it possible to consider the use of this type of current for the electrification of the main line railways. As this system seemed to be the one which also lent itself to the supply of the substations by three-phase current at industrial frequency under the best technical and financial conditions, it was upon this that the almost unanimous choice of the railways fell.

These considerations became so important that they not only imposed themselves upon the administrations which had not begun to electrify their railways, but certain railways already working on different lines for some years did not hesitate to reconsider their previous decisions.

This was the case when direct current was adopted in *France,* in 1920, in full agreement with the Midi Company which had already carried out in the Pyrenees electrification schemes on an

important scale with single-phase current.

The same thing took place in 1922 in the case of the Netherlands Railways which, having for many years operated with single-phase current the Rotterdam to The Hague line, decided to equip it with direct current when carrying out new electrifications.

In *Italy* the position presented itself in a very different manner owing to the extension of the low frequency three-phase system over all the north-western part of the Italian State system.

However the question remained unsettled for a very wide zone in the eastern and southern areas of the railway. Consequently it was decided, in 1919, to consider if it would not be as well, in order to facilitate the general electrification of this part of the country, to adopt for the new railway electrifications a different system of traction than that which had formerly given such good results.

The supply of current to the traction substations having to be by means of three-phase current at industrial frequency to meet the object proposed, the railway first of all had to see if it could use this type of current directly on the contact line : this test was made on the Rome to Avezzano line with three-phase current at 10 000 volts, 45-cycles. At the same period the Italian State Railways also experimented with direct current at 3 000 volts on the line from Benevento to Foggia.

The results obtained since 1927 on the Rome to Avezzano line have clearly shown that it is possible today to escape from the obligation of adopting three-phase traction, a frequency definitely less than the industrial frequency : thanks to the progress made in the last 30 years in mechanical and electrical work all the reasons which formerly imposed such a limitation are now eliminated.

The double contact line with the three phase system still forms an obstacle both technical and financial to the electrification of main lines run over by express trains. Moreover the three-phase induction motor does not lend itself any too well to the construction of locomotives which have to develop their full power at very different speeds. In addition the number of running speeds of these locomotives is necessarily rather limited and this makes it difficult to control them in a sufficiently accurate manner at high speeds.

All these difficulties are avoided when direct current at 3 000 volts is used, the results on the Benevento to Foggia line being considered sufficient to decide the application of this current to future electrifications, always with the exception of those to be carried out in the zone already given over to the low frequency three-phase system : for example the lines from Benevento to Naples and Bologna to Florence were in course of electrification in direct current at 3 000 volts when we prepared our report.

To sum up, in order to be able to adapt themselves to the present evolution, the Italian State Railways could not think of completely doing away with their former low frequency alternating current installations, like the Netherlands or Midi Railways were able to do, because these installations had already become too widely extended. But thanks to the fortunate concentration of these installations in a well-defined zone of their system, they were able nonetheless to select for new electrifications outside the zone in question a traction system in keeping with modern ideas.

G. — *Effect of this evolution on traction using alternating current.*

The almost unanimous favour recently given to direct current for traction purposes seems to indicate that this is the system which fits in most completely with the evolution of ideas in electrifi-

cation matters under the present technical and financial conditions. But it would be quite exaggerated to pretend that the advantages of a general nature that care is taken to follow up are exclusively attached to this system, because many solutions have been carried out or are proposed to *adapt, to modern tendencies, traction using single-phase current.*

In most cases low frequency single-phase current has been retained on the contact lines, the installations with three-phase current at the industrial frequency being supplied by means of *convertor groups.* This system which would have been considered a heresy by the early promotors of the single-phase system, is however only the logical sequence of present ideas on the linking together of generating stations and the common utilisation of the high-tension transmission lines. For this reason it has been adopted by the *Swedish State* Railways for all recent electrifications, and by the *Norwegian State* Railways for certain of their lines; it has also been applied on a large scale in countries outside those dealt with in our report and in particular in America.

The progress recently effected in the construction of mecury vapour rectifiers, transformed into valves by the addition of polarised grids, makes it possible to foresee in the near future the possibility of dispensing with revolving machinery for a conversion of this kind, and this would appear to promise further extensions of the use of this solution.

One may even think of going much further by endeavouring to use the industrial frequency *on the single-phase contact line.*

As we know, this solution was widely applied in the past, as the result of the use of a uniform frequency of 25 cycles per second for all purposes, a compromise between the 40- and 60-cycle frequencies generally preferred for the distribution systems and that of 15 or 16 2/3 cycles, better adapted to the requirements of single-phase traction.

But today an attempt is made to avoid this compromise by adapting the single-phase locomotive to frequencies of about 50 cycles per second: the successive sections of the contact line could thus be fed without changing the frequency by the different phases of a three-phase industrial frequency system, and the conversion of the current could be effected on the locomotives themselves before use by the motors. It does not appear however that this solution, recently tested elsewhere has been tried on any of the railways considered in this report. We will limit ourselves therefore to indicating that outside the type of rotary converter used for this test, certain constructors are considering a new solution of the same problem by installing on the locomotive a rectifier with polarised grids which feeds the motors without commutators.

Three-phase traction on its side has followed a parallel evolution.

We have already indicated how the *Italian State* Railways had shown, by a most interesting test, that it was possible to use in practice the industrial frequency on the three-phase current contact line.

On their low frequency three-phase current installations they have recognised, as did the Swedish State Railways for their low frequency single-phase installations, the value of feeding three-phase current at industrial frequency by *means of convertor groups.* Whereas the first electrified lines were fed at low frequency either by special power stations or by power stations in which there were both low frequency and industrial frequency alternators, thereby assuring connection with the private distribution systems, recent installations are fed by large substations which receive exclusively three-phase current at the industrial frequency and convert it

into low frequency three-phase current by means of motor-generator groups.

This shows to what extent the evolution of ideas in the matter of general electrification, which recently has caused a very marked movement in favour of the adoption of direct current for electric traction, has also reacted upon the design of installations for traction by alternating current.

H. — *Consequences common to all traction systems, whatever the type of current adopted for the contact line.*

The old installations using alternating low frequency current (three-phase current or single-phase current) were characterised by the fact that the primary current used to feed them was of the *same type* as the traction current used on the contact line: as we have just seen, recent developments tend to give up this idea which was thought to be essential in the beginning. The result has been that in the case of alternating current as well as direct current traction systems, the methods of feeding the new installations are *no longer influenced* by the type of the traction current itself. In particular, *whatever may be the system,* it is possible to avoid the construction of special generating stations, and even of high tension transmission lines exclusively given over to feeding the traction substations.

A great number of administrations have profited by these facilities to reduce to a marked extent their expenditure in connection with electrification by looking to private industry to supply the necessary energy and even in some cases to transmit it as far as the substations. They have been able to obtain by this method an appreciable reduction of the *cost price* of the current produced much more economically in very large power stations supplying a varied custom. Moreover thanks to the great capacity of the private power stations and to the development of their high tension distribution lines, the railway administrations have been able to secure to their electric operation the benefit of a *security of working* much greater than would have been the case if supplied by an isolated power station specially built for their own needs.

We may cite as an example the case of the Modane line of the Paris-Lyons-Mediterranean Company, where the annual consumption of energy for electric traction is less than 30 000 000 kw.-h., whereas the power stations of the private company supplying energy to the traction substations can produce 250 000 000 kw.-h. a year. On the same line the total power absorbed by traction for peaks of a duration of 5 minutes rarely reaches 10 000 kw., whereas the power of the groups installed in the hydro-electric stations of the supplier exceeds 70 000 kw. If it is noticed, moreover, that these power stations are distributed in several valleys in which the water supply conditions are very different and that their installation is completed by that of a lake at a high altitude forming a regulating reservoir, it is easy to appreciate that the railway could not obtain equal guarantees of security by means of power stations specially built for its traction service.

The same reasons in favour of the purchase of energy from private power station also prevailed on the *Algerian State Railways,* the *Morocco,* the *North of Spain,* the *Nord-Milano,* the *Netherlands* and the *Dutch East Indies Railways.*

Most of these railways have been able to avoid the necessity for constructing high tension distributing lines feeding power to their traction substations, by using the lines installed by their suppliers either especially for this object or for the general distribution of energy to their customers.

On the other hand other administrations have been obliged to build generating stations themselves and high tension

distribution lines because the development of the electric industry in the region considered was insufficient to meet the needs of a traction undertaking over a wide field. In order to be in a position to profit by the advantages of all kinds of which we have just spoken, the railways have been obliged, in this case, to put down generating stations of very great power and to connect them by high tension lines to private power stations or distribution systems. By this method, the railways have been able to dispose of their own surplus power, improve the use made of their high tension lines, and above all guarantee a great security of working to their undertaking.

We have already shown in the second part of this report the broad view taken by the French Midi Company in the Pyrenean region and the Paris-Orleans Company in the « Massif Central » in adopting this solution. On their side, the *Italian State* Railways — which had already been obliged to set up large low frequency power stations for the three-phase traction — have been obliged more and more to enlist the aid of all the most important private power stations. In the case of new electrifications, they hoped to be able to avoid building for themselves new power stations at industrial frequency, except naturally in those regions where energy would be lacking. The same solution has been adopted by the *Swedish State Railways* which in their recent electrifications at one and the same time feed their traction substations from their own power stations at industrial frequency and from private power stations. In *Norway* a slightly different solution has been adopted: the State power station produces low frequency single-phase current, but the traction substations are also fed by a private power station at industrial frequency, by means of converter groups and the linking together of these two methods of supply makes it possible to get the best use of the water power of the power stations.

This shows the great variety of interesting combinations that can be used for feeding the traction substations with three-phase current at industrial frequency, whatever may be the type of current used on the contact line.

I. — *Choice of the voltage for direct current traction.*

To terminate this part of our report concerning the selection of the traction current, we have still to indicate briefly the considerations which have to be taken into account in *selecting the voltage* in the case of electrifications using direct current.

The *French State* System alone keeps to 650 volts, nearly the same as that adopted more than 30 years ago for the first electrification carried out in the suburbs of Paris. In fact, up to now, the electification of the French State System has remained limited to the suburban lines, for which this voltage perfectly well meets the requirements. But this System considers that if the problem had not already been settled many years ago, it would at the present time be better to use the tension of 1 500 volts, which would favour the extension of electric traction to a region further out from Paris and which could be used, if need be, for electrifying the main lines of the system.

Outside the particular case we have just pointed out, since the war electrifications undertaken on the other French railways have all been carried out with direct current at 1 500 volts, owing to a decision taken in 1920 by the Ministry of Public Works as the result of an enquiry started in 1918. Mercury vapour rectifiers were at that time far from giving the reliability of operation that has since been assured thanks to the progress made in their construction; the adoption of 3 000 volts would have required the use

of motor-generators in the substations whereas the voltage of 1 500 made it possible to be satisfied with converters, appreciably less costly and with a better efficiency. Furthermore the perfecting of the 3 000-volt motors at that time appeared to offer certain difficulties to the European builders, especially as regards the motor coaches, the price of which also would have been appreciably greater than for 1 500 volts. It was thus the *technical and financial conditions of the moment* which led to the tension of 1 500 volts being selected.

The *Netherlands Railways* and *Dutch East Indies Railways*, moreover, came to the same conclusion.

On the other hand, the *Morocco Railways*, the *Italian State* and the *Nord-Milano* and finally the *Algerian State Railways*, profiting by the progress made in the electrical industry, did not hesitate to adopt the tension of 3 000 volts.

This tension of 3 000 volts was also selected by the North of Spain Railways for their first electrification on the Pajares line, in order to make the electrification more profitable thanks to the reduction in the number of substations. However, this railway returned to the tension of 1 500 volts when it was a question of electrifying a line including a well developed suburban service for which the construction of motor coaches at 3 000 volts was at that period not sufficiently perfected.

A large number of reasons which led most administrations to prefer the tension of 1 500 to that of 3 000 volts have today disappeared. On the one hand the mercury vapour rectifiers, which are capable of supplying economically this latter type of current, have undergone successive improvements which guarantee great security of action and justify the rapid extension of their use in recent years. The construction of the motor stock for 3 000 volts, including the motor coaches themselves, has also been successfully carried out by many European builders. The result is that this technical progress has appreciably modified the conditions under which at the present time the *financial balance-sheet* between the two tensions of 1 500 and 3 000 volts presents itself.

The motor stock at 3 000 volts remains however appreciably dearer than that at 1 500. Certain engineers moreover fear that a difference of the same extent, if not more marked, may be seen in the maintenance costs. The increased expenditure to be provided for under this head should therefore be taken into account when dealing with the savings that the use of a higher tension may produce on the fixed plant.

The result is that if the balance definitely favours 3 000 volts for the electrification of lines with a relatively small traffic in which case the expenditure on the fixed installations is much more important than that on the motor stock, the situation might be reversed in the case of lines with a heavy traffic requiring a considerable stock of locomotives or motor coaches.

It is therefore not suprising that the French Midi, having extended its electrification to lines with a very variable traffic, estimates that it would have been better had a tension of 3 000 volts been adopted in France. On the other hand the Paris-Orleans Company, the electrification of which affects exclusively a trunk line with heavy traffic and includes a section in the Paris suburbs, considers that the 3 000-volt tension would not have shown in this case a definite advantage over the 1 500-volt system. In the same way the Belgian National Railway Company which recently studied the electrification of its main line between Brussels and Antwerp has found that the 1 500 and the 3 000 volts are about equal as regards prices, the economies realisable on the lines and substations being absorbed by the higher cost of the tractor stock.

It appears therefore that at the present time, as regards electrification by direct current, there is an almost unanimous opinion in favour of 3 000 volts for lines not having a particularly dense traffic, but that the question of the choice of the tension remains very arguable for lines with very heavy traffic and especially for those which have also a well-developed suburban service.

QUESTION 3.

Résumé to serve as a basis for the discussions at the Congress.

a) Reasons which were responsible for the different solutions adopted in the past as regards the type of traction current;

b) General evolution of tendencies in the matter of electrification and the adaptation of different systems of traction to these modern tendencies;

c) Recent practical unanimity in favour of direct current;

d) Choice of voltage for direct current electrification.

QUESTION 4.

Safety measures.

A. — *Preamble.*

We have considered on the one hand that the question proposed dealt exclusively with the *safety of persons* (staff of the railway and others not employed by the railway), — and in addition that it was necessary to bring out the *safety measures specially applicable to electric traction* and not those concerning the use of electricity in general.

It is in this sense that we prepared the questionnaire addressed to the railway administrations, asking them to be good enough to keep these considerations in mind when answering.

It is also in this sense that we have dealt with the question in the present report.

B. — *Generating stations, high tension transmission lines and substations.*

The safety measures accepted by the railway companies either in the equipment of their generating stations, their high tension lines or their traction substations, — for the supervision and maintenance of these installations, — do not present any differences with those generally observed in installations of the same kind producing, transporting and distributing electric energy for other uses than for traction purposes.

We limit ourselves therefore to pointing out the special arrangements which have had to be taken in certain cases to prevent the usual safety measures affecting the maintenance of the high tension lines from having an undesirable repercussion on the regularity of working of the traction service.

To suppress completely any inconvenience of this sort, certain railway administrations have felt themselves obliged to install two independent lines so that it was possible to keep one of them under tension to feed the substations when current had to be cut off the other line for maintenance purposes.

In this way the Paris-Orleans Company feeds all its substations by means of two independent 90 000-volt lines carried on different pylons, the distance between the two lines being about 20 m. (66 feet).

For feeding the substations on the Modane line the Paris-Lyons-Mediterranean Company also installed a double high tension line; but as it had been content with the tension of 42 000 volts adopted previously for the distribution system of the company supplying the energy it was possible to carry the conductors of the two lines on the same sup-

ports. These have however been designed in such a way that the minimum distance between the conductors closest together of the two different lines is never less than 3.60 m. (12 feet); thanks to this wide distance apart and the particular arrangement of the pylons it is possible to work on one line while the other is kept under tension. It has therefore been possible to obtain the same facilities as with separate lines on separate pylons the cost of which is much greater.

C. — *Overhead contact lines : general measures.*

In order to call the attention of the public to the danger of making contact with overhead traction lines, the general practice has been to put up in the stations, at level crossings or on structures crossing the permanent way *notices calling* attention to this danger and forbidding anyone to touch the overhead lines.

In the case of *bridges* or *footbridges* crossing contact lines, these measures have in most cases been amplified by fitting above these lines metal plates or expanded metal screens on each side of the structure for a width of 1 to 1.50 m. (3 ft. 3 3/8 in. to 5 ft.) and fitted with earthing wires).

In certain cases the open sides of bridges or footbridges have been closed in by plain panels; the Netherlands Railways have even put up completely enclosed footbridges.

Outside the substations and the sectioning or paralleling posts, — for which signalling lamps are widely used —, usually there is no *light signalling,* indicating that the contact lines are under tension in the stations or between them.

The railway administrations limit themselves to laying down, either in the instructions distributed to the staff or by notices for the public, that the *contact lines should always be considered as being under tension.*

Certain railway systems have however thought it desirable to complete these prescriptions by light signals; but to meet the danger of a light going out unexpectedly, it is then specified that *if the lamps being alight is to be considered as a positive indication,* the lights being out does not excuse any faiture to take the measures required to make certain that the current has been cut off and that the contact lines have been earthed.

With these formal restrictions the system of light signalling of contact lines has been installed by several railway companies upon the locomotive shed lines and the shop lines. The Paris-Orleans Company has even extended this system in certain stations by means of groups of lamps arranged in cluster form and the Paris-Lyons-Mediterranean uses luminous tubes containing rarified gases to facilitate the carrying out of shunting operations on certain service lines and particularly to prevent an electric locomotive being sent on a line the contact line of which has been earthed; finally in order to reduce the risks of the lamps going out unexpectedly each arrangement consists of two light tubes working in parallel.

In order to guarantee the safety of the public and the station staff *during loading and unloading wagons,* nearly all railways definitely forbid this work to be carried out under overhead lines under tension. The current is usually cut off from the overhead line by means of a section switch which in its open position earthes the portion of the line under which the work is being done. Usually the switch has to be padlocked in this position and the key of the lock is kept by the employee responsible for working this part of the station; in most cases it is also laid down that the section switch is only to be closed if the line has to be put under tension to carry out a shunt with an electric locomotive and to relock it in its open and earthed position as soon as this operation is finished.

In carrying out various light repairs to rolling stock, the men have to get on the *roof of the carriages or wagons :* All the railways absolutely forbid this work to be done under overhead contact lines under tension. If it is necessary to carry out these operations on lines with overhead contact lines, the latter should first of all have the current cut off and be earthed.

The attention of the staff is also called to the danger existing in the contact lines as regards the train staff when in the *raised brake shelters* on goods wagons.

On certain railways the staff are not allowed to occupy these raised brake shelters unless no wagons fitted with brake shelter on the floor level are available.

Other railways only allow train staff to occupy raised brake shelters if these are entirely closed.

D. — *Level crossings on lines equipped with overhead contact lines.*

Outside the *notice-boards* calling the attention of the public to the danger of the contact lines at level crossings, special measures are often prescribed to assure the safety of the road traffic.

Certain railways such as the *Paris-Orleans* and the *North of Spain* on which the contact line is normally installed on the open track at less than 6 m. (19 ft. 8 in.) above rail level, the contact line has been raised, when possible to 6 metres at the level crossing.

Several administrations have installed on the road, on both sides of level crossings, loading gauges for the road vehicles in order to prevent vehicles with too high a load which might come in contact with the contact line from crossing or even from getting too close to it : for this purpose these gauges are generally set up to a dimension which is 0.50 m. (20 inches) below that of the contact line, sometimes even more. They usually consist of very light gantries or of ordinary cables stretched across the road : on the *Italian State* Railways, the protection cable which connects all the pylons of the contact line is purposely placed 0.30 m. (12 inches) below this line. On certain railways the gauges carry notices and sometimes even acoustic devices (bells).

The great French Railways (*Midi, Paris-Orleans* and *Paris-Lyons-Mediterranean*) do not install any gauges unless the contact line is less than 6 m. (19 ft. 8 in.) above rail level. Other railways such as the *Italian State, Nord-Milano, Norwegian State, Dutch East Indies* and *Morocco Railways,* fit gauges of this kind at all important level crossings, regardless of the height of the contact line, — or even at all level crossings without exception regardless of the amount of road traffic.

In the case of supervised level crossings, even when fitted with gauges, it is generally laid down that the crossing keepers shall supervise the loading of the vehicles coming onto the level crossing.

E. — *Pylons carrying the contact lines and neighbouring metal structures.*

In order to avoid the danger which might arise as regards the public and staff through the current unexpectedly coming onto the pylons carrying the contact line in the case of damage to these latter or through defective insulation, two distinct methods have been utilised.

The most simple and the most economical system consists in *fitting each pylon with an earthing plate :* this arrangement has been considered sufficient by the *North of Spain* Railway, on the lines of the *Midi* system fitted with the automatic block and on those of the *Paris-Orleans* Company (except in certain special cases).

The second method consists in *connecting the pylons to the running rails*

by suitable connections : this system has the drawback of being more costly than the first but it makes it possible to obtain more certainly the release of the switches of the substation or of intermediate posts in case of any defect on the contact lines. This is the reason why the *Paris-Orleans* Company which generally is satisfied with the earthing plates which we have just mentioned, thought it necessary to use in certain cases connections between the pylons and the rails. On its side, the Paris-Lyons-Mediterranean Company has generalised this latter system after having employed at the beginning separate earthing plates. The pylons are also connected to the running rails by the *Netherlands* Railways, *Dutch East Indies*, the *Nord-Milano* and the *Norwegian* State.

On the *Nord-Milano* these connexions are formed by a round steel bar 16 mm. (5/8 inch) in diameter, electrically welded to the pylons and to the foot of the rails; the *Netherlands* Railways use either one or two bare copper wires of 50 mm^2 (0.077 in^2) area; on the *Paris-Lyons-Mediterranean* Railways, copper cables lightly insulated, 105 mm^2 (0.163 in^2) in section are used.

We would also point out that certain railway systems have *combined the two methods*. On the lines of the *French Midi*, not fitted with the automatic block, the two arrangements have been used at the same time, that is to say the pylons are fitted with earthing plates and at the same time are connected to the rails. Other railway systems have completed one of the methods by arrangements derived from the other : in this way the pylons on the *Morocco* Railways have individual earthing plates but are also connected to a negative feeder connected to the rails at intervals; on the other hand on the *Algerian State* Railways each pylon is connected to the rails, but these are fitted with earthing plates every kilometre (0.62 mile). Finally the pylons on the *Italian State* Railways are connected together by a protecting cable connected in turn to the rails every 4 or 5 supports and the rails are in their turn fitted with earthing plates about every 500 m. (0.31 mile).

Identical measures are generally taken to earth or to connect to the rails the *metal structures* near the contact lines : bridges, signal gantries, metal frames of station roofs, etc...

F. — *Maintenance of overhead trolley wires.*

Some of the railways using 1 500-volt direct current allow certain urgent repair work, when not too extensive, to be carried out on *the contact lines whilst under tension.*

For example, the maintenance gangs of the *Paris-Orleans* Railway can be authorised to carry out slight repairs on condition that they use insulated ladders or platforms and put at the same potential (either by means of section switches if these exist, or by means of portable connexions) all nearby conductors with which the workman might accidentally come into contact while doing his work or even when getting to the place where the work has to be done.

The *Netherlands* Railways operate in the same fashion when the repair will only take a very short time, as for example the removal of a broken suspension wire; but the authorisation to work on a trolley wire under tension is only given when the weather is dry and on condition that really dry ladders are used and that the men keep themselves sufficiently far away from details that are earthed or even under a different tension.

The *North of Spain* Railway authorises small repairs, such as tightening up a wire, replacing a support that has become displaced, etc., to be carried out on 1 500-volt lines under tension, wooden ladders resting on insulators being used. This practice is not however al-

lowed on the Pajares line where the tension is 3 000 volts and over which the intensity of traffic is appreciably less than on the lines electrified with 1 500 volts so that it is not necessary to carry out repairs so quickly.

All the other railways forbid any work under any circumstances to be done on trolley wires under tension, even when this tension is only 1 500 volts.

Switching the current off the trolley wire prior to carrying out any repair work (for important work on the first railways and for all repairs on the others) is done by operating the circuit breakers in the substations or intermediate stations, completed, if the case arises, by opening the local section switches by means of which the current can be restored on the trolley sections not directly affected by the work.

These appliances are operated by competent staff at the request of the man in charge of the repair gang according to the instructions or orders wherein are laid down the detailed steps to be taken to prevent the current being restored too soon (padlocking the appliances, putting up notices, etc.).

In addition, the action of cutting off the tension has to be completed in all cases by *earthing* (or to be more exact by making connexion with the rails) this being done by the repair gang on each side of the work even when the circuit breakers and section switches cutting off the current have already been earthed for the portion of the trolley considered.

The appliances used to earth the trolley wire at the point where the repairs are being carried out differ in type according to the railway; they generally include a metal clamp intended to be fastened to the foot of the rail and connected by flexible insulated copper cables to a clip of various forms mounted on an insulating pole. Obviously the clamp has first of all to be fastened to the rail and only after this has been done is the other clip to be hooked onto the trolley wire; the operations have to be carried out in the reverse order when disconnecting the earth, which must moreover always be done before making a request for current to be put on the line again.

The *Paris-Lyons-Mediterranean* Railway specifies in addition that at each place at which work is being carried out a sufficient number of earthing appliances are to be used so that no workman shall work at more than 100 m. (330 feet) from one of them; each job should be protected by itself without taking into account any work being done nearby, unless one man is supervising them all.

Similar precautions are taken in the case of work not on the trolley wires themselves but *nearby*.

Usually all that is required is that the trolley lines shall have the current cut off and be earthed when any work is being done within such a distance that a workman can accidentally come into contact with them. This distance is left generally to the decision of the foreman carrying out the work; the *Algerian State* Railways however fix this at one metre.

The *Paris-Lyons-Mediterranean* also lays down that within 50 metres (164 feet) of every man working near a trolley wire under tension there shall be an earthing device ready for use, i. e. with its clamp connected to the running rail and the other end ready to be put on the trolley wire in case of urgency.

In order to prevent the prescribed safety measures to be followed when maintaining the trolley wires from causing too great interference with the working of the railway, the administrations generally have tried to accelerate these operations by putting at the disposal of the maintenance gangs *portable telephones* which enable them to get into touch with the substations or the nearby stations.

These telephones can be put into service either by means of poles hooked on the telephone wires or by means of fixed connexions set up at intervals along the line on a special circuit : such connexions are for example installed every 250 m. (820 feet) on the Modane line of the *Paris-Lyons-Mediterranean* Railways and every 300 m. (984 feet) on the *Paris-Orleans* lines; on the *Italian State* Railways telephone posts have been provided all along the line every two kilometres (1.24 miles) at the most.

Some railways have in addition provided arrangements whereby the tension can be taken off the trolley wires without the intervention of the substations. The *Paris-Orleans* Railway has even installed, on its most frequented sections, circuit breaking boxes every 300 m. (984 feet); but this arrangement which causes the switches in the substations or intermediate stations to open should not be used except in definite cases of urgency.

G. — *Steam traction on lines fitted with overhead contact lines.*

The attention of the *staff handling steam locomotives* having to run over electrified lines with overhead trolley wires is called to this danger by notices placed in the depots or by instructions distributed to the men; some administrations in addition post up in the locomotive cabs notices briefly pointing out this danger.

On nearly all the railways it is *forbidden to climb upon* the tender or on the upper part of steam locomotives running under trolley wires; certain railways allow some relaxation of this regulation in cases of absolute necessity, while recommending in such cases the greatest care and forbidding the men to stand upright. In certain cases notices or other methods are used to call the attention of the staff to points at which the trolley wire is brought lower so that they can take even greater care.

The locomotive staff are generally warned *not to use the fire irons,* except with the greatest care when under a trolley wire; on certain railways this is even definitely forbidden. To lessen the danger from the firing tools being carelessly handled the *Paris-Orleans,* the *Netherlands,* and the *Algerian State* Railways have fitted behind the locomotive cab a screen or extension limiting the movements of long tools. The *Paris-Lyons-Mediterranean* Railway after having fitted up this arrangement subsequently replaced it by another method already used in Switzerland and which consists in fitting on the tender a very large tube in which the fireman can place the irons as he withdraws them from the firebox, or inversely, so that he does not run any risk of letting them project above the cab.

The railways also call the attention of their staff to the precautions to be taken when *watering the coal* on the tender near the overhead lines and on the necessity of avoiding *throwing water* either through excessive use of the blower or by priming when starting

On the *Nord-Milano* the steam locomotives are in addition fitted with an arrangement to prevent the colum of steam and water from the safety valves from reaching the overhead lines.

We will also mention certain measures which, while tending especially to protect the overhead lines from being damaged, nonetheless indirectly affect the safety of the staff. Such, for example, is the regulation laid down by the French *Midi* to take care not to stop the steam locomotives with the chimney under an insulator of the trolley wire, or even near it : if for any given reason this regulation cannot be strictly observed the use of the blower is then definitely forbidden. With the same object of avoiding damage to the trolley wires the *Paris-Lyons-Mediterranean* Company has fitted

deflectors to the chimneys of boilers fitted in the trucks used to steam heat the vehicles in the electric trains on the Modane line.

H. — *Lines equipped with third rail : general requirements.*

In addition to the notices or warnings calling attention to the danger of death which might result from accidental contact with the third rail, an endeavour is made to diminish the risk by using *guard boards.*

When dealing with tensions of 600 to 700 volts, the third rail is not generally protected except in stations or at points accessible to the public such as near level crossings, but no protection is provided on the open lines on which only men accustomed to the danger and knowing how to take the necessary precautions are employed. On the French State Railways, where the current is picked up from the under side of a rail of rather special section, the protection simply consists of plates of fused basalt placed on the third rail itself. All the other railways, using a rail from which the current is collected from the upper face, fit insulated guard boards.

On the Modane line on which the tension is 1 500 volts, the *Paris-Lyons-Mediterranean* Company has thought it necessary to install a continuous guard, *even on the open road,* consisting of three lines of creosoted boards (two at the sides and a third above the rail); this guard is carried by the rail itself, insulators (of porcelain, earthenware or fused basalt) being inserted between the web of the rail and the metal parts holding the boards together.

This Company, like the *Italian State Railways,* connects to the running rails by copper connexions any metal parts near the third rail, or those in which there might possibly be a dangerous potential through the return current.

As a result of the regulations adopted for lines fitted with overhead trolley wires, *loading and unloading* of wagons can only be carried out on a line fitted with a third rail when the portion of this rail affecting the track in question has previously been made dead and earthed by means of suitable section switches and in accordance with the methods indicated previously.

The examination of and running repairs to rolling stock on lines fitted with a third rail should not be carried out usually until the current has been cut off and the line earthed. Cases arise however in which certain work of this kind (such as the inspection of the brake and the running gear) can only be carried out when the trains are at a station, or are standing on a line where the current cannot be cut off the third rail nor the latter be earthed : the attention of the staff is then especially called to the danger resulting from the proximity of the third rail in spite of the guard boards with which it is fitted; these guard boards can moreover be of a type specially designed to meet this particular case and differing from the type normally used on the other lines (this has been done for example in the case of certain lines in the Modane station on the *Paris-Lyons-Mediterranean* Railways.

I. — *Maintenance of tracks with third rails.*

On the *Paris - Lyons - Mediterranean* Railways no work is allowed to be done one the 1 500-volt third rail nor to its guard without the third rail having previously been *made dead and earthed.*

The methods prescribed are moreover identical with those indicated previously for the maintenance of overhead lines, except that the apparatus used on the work to earth the third rails is of a different type.

Railways using a voltage of 600 to 700 volts only, on the other hand, allow light repairs to be carried out when the third

rail is *under tension*. For example in the case of urgent small repairs the men on the *French State* Railways can do the work without making the third rail dead on condition that they wear rubber gloves, stand on a dry plank, and take care not to touch both the third rail and a running rail. In the same way the *Italian State* allows certain work such as repairs to the insulators, connexions, etc., to be carried out without cutting off the current from the third rail provided the men use insulated platforms. For other work this railway insists not only on the current being cut off but on the rails being earthed, whereas the *French* State Railways does not require the rails to be earthed after the current has been cut off unless it is a question of work of some extent.

In the case of work carried out not to the third rail itself *but near to it*, it is not necessary to cut off the current from the third rail; the staff should however take the necessary precautions to avoid any accidental contact and to protect themselves by means of *shields* made of planks laid on the third rail.

The *Paris-Lyons-Mediterranean* Railways, however, only allow work to be done under these conditions when the guard boards on the 1 500-volt third rail are dry and provided additional precautions given in each case in a special order are carried out. It is laid down for example that before starting work there should be placed on each side of it an apparatus for earthing the rail, ready for use, i. e. with its clamp secured to the running rail; moreover a portable telephone has to be permanently connected into the special circuit near the place where the work is to be done. The tool equipment has to be checked over beforehand and is to consist only of the tools the use of which is authorised on the electrified lines, that is to say : forks and shovels with short sockets, short picks and beater picks with the metal part less than 0.60 m. (2 feet) long, spanners with wood handles, long keys, the top part covered with insulating material. In addition the staff is forbidden to leave any metal parts longer than 0,60 m. (2 feet) near the conductor rails, or to walk on the guard board or to place anything on it. Before and after doing the work, the man in charge calls over the staff at a place laid down beforehand; when the work is done he makes sure that all the materials and tools have been collected.

J. — *Electric locomotives and motor coaches.*

It is the general practice on all the railways only to provide *one man to drive a rail motor coach*, the driving compartment being fitted with the apparatus known as the «*dead mans' handle*» which automatically cuts off the current and applies the brake in case anything goes wrong with the driver, i. e. when this latter ceases to press either with his hand on the driving handle or with his foot on a pedal placed at the base of the controller; the *Italian State* has also under trial an arrangement to secure the same result without obliging the driver to press down the whole time on the handle or the pedal.

On certain railways, such as the *French Midi* and *Italian State*, the head guard also travels in the same place as the driver of a rail motor coach; on other railways, such as the *Paris-Orleans* and *North of Spain*, the head guard does not travel in the driving compartment but immediately next to it in order to be able to watch the conductor and intervene in case of urgency; this arrangement is also followed on the *Netherlands* Railways, with this difference however that the head guard has to take his place in the driving compartment in case of heavy fog or anything going wrong with the continuous brake.

On the other hand *electric locomotives* are most often handled by *two men*

of the locomotive running department : an electric locomotive driver and an assistant.

On the *French State, Midi, Paris-Orleans* and *Morocco Railways* there is a tendency however to utilise the head-guard in place of the second locomotive department man, when driving certain trains, especially trains fitted with the continuous brake. On the *Norwegian State* Railways electric locomotives hauling trains fitted with the continuous brake are now being driven by a single man to a large extent. Finally the *Italian State* Railways have fitted two of their locomotives with the Brown-Boveri arrangement for one-man driving : this test too is only being made on trains fitted with the continuous brake.

Most of the railways (*Paris-Orleans, Paris - Lyons - Mediterranean, Algerian State, North of Spain, Italian State, Nord-Milano*) have taken care to *make it impossible to get at the high tension equipment of the locomotives* by fitting shutters or panels of wire netting which cannot be opened unless the tension has previously been cut off. On certain railways these panels are fitted with locks, the keys of which are *interlocked* with the control gear of the pantograph in such a way that the panels cannot be opened until the pantographs have been lowered and locked in their lowest position; this interlocking is moreover reciprocal, i. e. it is not possible to raise the pantograph so long as the panels protecting the high tension equipment are not in place and locked up.

Like measures have sometimes been taken in the case of *rail motor coaches* by arranging the equipment either in a special cabin (*Nord-Milano* and *Dutch East Indies* Railways) or in boxes placed under the frame (*Paris-Orleans* Railway), the doors of this cabin or of these boxes being interlocked by means of reciprocal locks with the control of the pantograph. The *Netherlands* Railways have found it sufficient to place on the roof of the rail motor coaches a main switch which can be operated from the ground by means of an insulated pole and by means of which the staff can cut off the current on the whole of the equipment and earth it before getting onto it.

The same care has been shown by certain railways to *prevent access to the roof of the locomotives* as long as the pantographs have not been previously lowered and locked in this position. In this way, on the locomotives of the *Paris-Orleans, Paris-Lyons-Mediterranean, Algerian State* lines, and the *North of Spain,* the steps giving access to the roof are normally folded up and locked up by means of a key which is conjugated by reciprocal interlocking with the control of the pantograph, following the same arrangement as for the protecting shutters of the high tension equipment.

A similar safety device is evidently not applicable to *current collecting shoes* on lines fitted with a third rail : in order to avoid the danger of unexpected contact as far as possible the top of the shoes of the locomotives of the *Paris-Lyons-Mediterranean* are protected by a large cover of insulated material carried by brackets which are earthed.

Among the parts of the electrical equipment likely in certain cases to present some danger, mention may also be made of the *high tension connections between the vehicles,* such as those for the electric heating of the coaches. To avoid the danger which might occur, when coupling or uncoupling such cables under tension, some of the railways interlock the end junction boxes with the switch feeding this circuit on the locomotive, by means of reciprocal locks.

In the case of *anything going wrong on the open line,* requiring an examination or a repair to a part of the high tension equipment, all railways equipped with overhead lines require the pantograph first of all to be lowered and to

be locked in this position : this operation is moreover made materially essential on certain railways by the arrangements of which we have spoken above. Several railways, in particular the *Paris-Orleans, Paris-Lyons and Mediterranean, Algerian lines of the State, Morocco* and the *Norwegian State* Railways, also require, if it is necessary to climb upon the roof, that the current must be cut off the line beforehand, and then the man must protect himself by means of *the earthing poles provided on the locomotive.*

On the lines of the *French State* Railways fitted with third rails at 650 volts, the shoes have to be insulated before any inspections or repairs are carried out on the open line.

On the *Paris - Lyons - Mediterranean* lines with third rail at 1 500 volts, any operation on the collector circuit or the shoes themselves can only be carried out after the current has been cut off and after having connected the third rail to the running rail by means of the earthing gear carried on each locomotive : in case of emergency this gear can be used to make a complete short circuit between the third rail and the running rails and thereby throw out the switches of the substations or the intermediate stations (this possibility is moreover special to the gear for earthing the third rail, whereas the earthing gear for the overhead trolley wires must never be used until the current has been cut off by the switches of the substations or intermediate stations).

The locomotives of the Paris-Lyons-Mediterranean Company are in addition fitted with a pneumatically controlled contactor operable from each driver's compartment and by means of which it is possible to make a full short circuit between the running rails and the third rail, or the overhead trolley wire in case of anything going wrong such as arcing starting in the equipment; thanks to this earthing contactor it is possible to immediately stop an arc which is insufficient to throw out the switches of the substation or the intermediate station but which if allowed to continue might cause serious damage to the locomotive equipment.

We will call attention finally to the fact that in order to facilitate the work of the locomotive men in case of anything going wrong on the journey, most of the railways fit these locomotives with *portable telephones* by means of which they can get into communication with the nearby stations or the substations.

As a safety measure, the locomotives and rail motor coaches are *repaired at the depots* most frequently on tracks not fitted with contact lines.

This is not so in all cases when *running repairs* are being done but the contact lines (overhead trolley wires or third rails) of the tracks set aside for these repairs are then fitted with section switches by means of which it is possible to take the tension off them and to earth them before starting the work; on certain railways these section switches are fitted with optical arrangements (discs or lamps) to show that the necessary steps have been taken.

In addition to this fundamental protection, certain railways require additional precautions to be taken, such as putting up discs carrying the words : « Do not put into service, work being done on the engine », — requiring the workman to make sure himself that the contact lines have been earthed, the pantographs lowered and the main circuit switches are open, etc.

On the *Paris - Lyons - Mediterranean* Railways the foreman, after having padlocked the section switch of the contact line in the open position, hands to each man of the gang a check carrying the same number as the key padlocking the section switch and authorising the workman to work on the track in question: after the work has been done the workman hands back the check to the fore-

man who should not close the section switch until he has made sure that he has all the checks marked with the same number as the key in his possession.

Finally in the case of exceptional work to be carried out urgently on a shed line the contact line of which cannot be earthed, the same precautions as when dealing with work on the open line have to be taken.

K. — *Miscellaneous.*

In addition to the usual measures taken against *fires* in the generating stations and substations, the railways generally fit all their locomotives and electric rail coaches with chemical fire extinguishers; most frequently these are carbon tetrachloride extinguishers and in order to make it possible to use them under all circumstances without the staff being placed in any danger through the release of dangerous gases, an extinguisher is provided in each driving compartment close to the door. In adition, the *Paris-Lyons and Mediterranean* Company provides respirators which are carried near each extinguisher.

The usual method of rendering first aid to persons accidentally hurt on the railway lines is completed in the case of electrified lines by special arrangements to deal with cases of *electrocution.*

As in all electrical installations, notices widely distributed indicate the methods to be used for *artificial respiration* by the usual methods and especially the Schaeffer method.

The *Paris-Orleans* and the *Morocco Railways,* in addition, have fitted their substations, locomotive depots and important stations with *the Panis apparatus* by means of which artificial respiration can be given by mechanical means. The *Paris-Lyons-Mediterranean* Railways has even extended the distribution of these appliances to signal boxes on the open line, to level crossing keeper's houses and to permanent way men's shelters so that the men of the maintenance gangs have always one of these equipments near the place of work : the Panis equipment has also to be taken out to the work if it is a question of carrying out repairs near the third rail without cutting off the current. On the *Italian State* Railways in the same way, a special stretcher designed by Dr. Zumaglini is used to give artificial respiration mechanically.

The *French Midi* Company uses in addition oxygen inhalors; finally the *Paris-Orleans* and the *Paris-Lyons and Mediterranean* Companies provide in the substations, locomotive depots, stations and certain signal boxes on open line, the necessary equipment for giving ether injections.

In addition to the usual methods of communication provided on all railways to meet the normal or occasional operation needs, electrified lines usually have *supplementary telephone circuits* for their special requirements: these supplementary methods of communication are not only provided to make sure that the electric service is working regularly by accelerating the maintenance operations or by making it possible to make good the position in the case of anything going wrong in any part of the equipment, but they have many great advantages in the case of *accidents to people.*

In this respect we should point out the installation of a *direct circuit* between the power stations, substations and the head of the department, — and especially the rather widely extended installation of a special circuit, sometimes known as *the relief circuit* which connects up not only the substations, stations, and the locomotive depots, but also certain signal boxes on the open lines at very short intervals: as we have already shown this emergency circuit is sometimes so arranged that the permanent way and the contact lines maintenance men, as well as the locomotive

and rail motor car men, can easily switch their portable telephones on to it. An installation of this kind obviously forms one of the best methods for getting help quickly in the case of accidents to people at any point of the electrified line.

L. — *Results obtained.*

In order that the Congress may appreciate the *efficacy of the safety measures* taken by the railways on their electrified lines we asked them to supply as detailed accident statistics as possible. Most of the railways consulted have only given rather brief information, certain of them not even replying on this point. It therefore appeared interesting to us to reproduce first of all the replies of the administrations who have been good enough to supply detailed statistics and then to indicate the more or less summary information supplied by the other railways: this done we will endeavour to bring out certain conclusions.

The *French State* which has 254 km. (158 miles) of single line electrified in the Paris suburbs with third rail at 650 volts, with an annual traffic of 4 900 000 tr.-km. (3 044 800 train-miles), for the 2 years 1929 and 1930, supplied the following information relating to the two years in question :

	1929	1930
1. *Fatal accidents :*		
a) Railway staff :		
Substations	1	0
Electrified lines	1	0
b) Persons not employed by the railway :		
Electrified lines	1	0
Total	3	0
2. *Non-fatal accidents :*		
a) Railway staff :		
High tension cables	1	1
Substations	0	2
Electrified lines	0	0
Driving staff	5	2
Depots and shops	13	6
b) Persons not employed by the railway :		
Electrified lines	3	0
Total	22	11

The *Paris-Lyons-Mediterranean* Company, with 266 km. (165 miles) of single line electrified with direct current at 1 500 volts, the major part with third rail, and the remainder with overhead trolley wire (sidings) has supplied statistics from the beginning of electric traction on its first section and continuing until the whole line was put into full service. These statistics are given in the following form :

1. *Fatal accidents :*	1926	1927	1928	1929	1930	1931 (first 6 months).
High tension lines	0	0	0	1	0	0
Substations	0	0	0	0	1	0
Third rail	0	0	0	3	0	1
Trolley wires	0	0	0	1	0	0
Locomotives	0	0	0	0	1	0

2. *Non-fatal accidents :*	1926	1927	1928	1929	1930	1931 (first 6 months).
High tension lines	0	0	0	0	0	0
Substations	0	0	0	0	0	0
Third rail	1	0	0	4	5	0
Trolley wires	0	0	0	0	1	0
Locomotives	0	0	0	0	0	0

It is pointed out in addition that the fatal accidents which occurred on the high tension lines and two of those attributable to the third rail were not to railway employees but to workmen employed by contractors working for the railway; among the non-fatal accidents the one due to the overhead line and two of those ascribed to the third rail took place under the same conditions; finally three of the non-fatal accidents due to the third rail were to temporary workers in the railway maintenance gangs, but who were not on the permanent staff. No accidents due to the electric traction equipment occurred to any member of the public.

On its system including 2 210 km. (1 373 miles) of electrified single line and on which the annual train mileage in 1929 exceeded 6 210 000 miles, the *Midi Company*, in the 2 years 1928 and 1929, only recorded 6 fatal accidents and 11 non-fatal accidents ascribable to the electric traction equipment.

The *North of Spain* Railways estimate that there is one fatal accident for every 2 500 000 tr.-km. (1 553 500 train-miles): no fatal accident however occurred to people not belonging to the railway.

In a period of 5 years, 1926-1927 to 1930-1931, the *Italian State* Railways have only had 25 serious accidents 24 of which were fatal : 20 of these accidents were to men employed by the railway and 5 only to people not in the railway service, as follows :

Year	Railway staff	Persons not employed by the railway
1926-1927	4	0
1927-1928	8	2
1928-1929	2	0
1929-1930	5	2
1930-1931	1	1

During this period the length of electrified single line has grown from 2 132 to 3 338 km. (1 325 to 2 074 miles) and the annual distance run by electric trains has risen from 16 millions km. (9 942 000 miles) in 1926-1927 to 23 400 000 tr.-km. (14 540 000 tr.-miles) in 1929-1930 to fall to 22 300 000 km. (13 857 000 miles) in 1930-1931.

It is moreover due to the rapid extension of electrification in certain years that the increase in the number of accidents in 1927-1928 and 1929-1930 was due.

Actually nearly all these accidents were due to the manifest carelessness of the victims.

In 2 years of operation, the *Nord-Milano* Railways have had 2 fatal accidents, one to a workman on the trolley wire maintenance gangs and the other to a driver : the length of single line electrified is 135 km. (84 miles) and the annual distance run by the electric trains is about 700 000 km. (43 500 miles).

Since 1926 the *Netherlands* Railways have only recorded one fatal accident and 4 non-fatal accidents on a system of 461 km. (286 miles) of electrified single line and an annual distance run by trains of about 5 millions (3 107 000 miles).

The *Dutch East Indies* Railways have only had 2 fatal accidents both due to carelessness on the part of the men.

For the year 1929-1930 the number of accidents on the *Norwegian State* Railways is only 0.42 per million km. (0.67 per 1 000 000 miles) run by electric trains, for fatal acidents, and also 0.42 for non-fatal accidents.

The first indication to be drawn from these figures is that the *safety measures* taken by the electrified railways have been *very efficacious*, seeing that very few accidents have occurred to the staff and that the public is generally completely protected from accident.

The statistics show, moreover, that the

position *steadily improves* as the staff becomes accustomed to the safety measures laid down: it was especially when electrification started that accidents were to be feared owing to the *lack of experience* of the staff; the same remark applies to contractors' men or to labourers temporarily employed by the railway.

We shall never entirely avoid accidents due to acts of *obvious carelessness* that even the most experienced men sometimes commit. Nevertheless, however, in order to reduce the number of accidents, steps should be taken to train in a methodical way men not yet accustomed to the dangers of electrification, especially newly recruited staff, such as men temporarily employed to strengthen the permanent way maintenance gangs on the electrified lines or men belonging to contractors working for the railways.

4th QUESTION.

Résumé to serve as a basis for the discussion at the Congress.

a) Measures concerning the public safety and that of the staff in general on electrified lines.

b) Measures concerning the safety of the staff responsible for the maintenance of the overhead trolley wires fitted or of lines with a third rail.

c) Measures concerning the safety of the staff responsible for driving and maintaining locomotives and electric rail motor cars.

d) Safety measures affecting steam traction over electrified lines.

e) Assistance in case of accidents due to electricity.

f) Special supervision to be exercised over workmen not belonging to the permanent staff of the railways.

Questions.	— 1	French State Rys. 2
1	Total length of the system, in kilometres	9 064
2	Length of electrified lines, in kilometres	111.6
3	Length of single track, in kilometres	3.4
4	Length of double track, in kilometres	108.2
7	Total length of electrified lines (including secondary lines), in kilom.	254.150
8	Number and length (in km.) of tunnels electrified	11 — 5.820
9	Annual train-kilometres (passenger)	4 878 000
10	Locomotive-kilometres (passenger)	1 321 000
	Rail motor coach-kilometres (passenger)	10 960 000
11	Gross ton-kilometres hauled (passenger)	1 160 529 257 incl. 618 709 000 r. m.
12	Annual train-kilometres (goods)	5 000
13	Locomotive-kilometres (goods)	5 000
	Rail motor coach kilometres (goods)	...
14	Gross ton-kilometres hauled (goods)	2 118 625 of which 300 000 by loco
26	Are you carrying out a programme of electrification ?	Programme carried out.
27	Extension of your electrification — to what extent ?	Extensions into suburbs.
30	Number of electric locomotives (passenger)	39
31	Total weight and adhesive weight of the most powerful type.—Type.	62 640 t.
32	Power of the most powerful type, hourly rating	1 100 H. P. at motor shaft.
33	Tractive effort, hourly rating	4 400 kgr. at the rim.
34	Number of electric locomotives (goods)	30 out of 39 used for pass. and goo
35	Total weight and adhesive weight of the most powerful type.—Type.	...
36	Power of the most powerful type, hourly rating	...
37	Tractive effort, hourly rating	...
38	Number of rail motor coaches	183
39	Total weight and adhesive weight of the most powerful type	57.5 t.
40	Power of the most powerful type, hourly rating	660 H. P. at motor shaft.
41	Tractive effort, hourly rating	1 400 kgr. at the rim.
42	Number of electric shunting locomotives	30 locos. under quest. 34 do shunti work.
43	Total weight and adhesive weight of the most powerful type.	...
44	Power of the most powerful type, hourly rating	...
45	Tractive effort, hourly rating	...
46	Average annual kilometres run { locomotives	31 230 km.
	{ rail motor coaches	59 890 —
47	Are locomotives driven by regular men or are they pooled?	Pooled.

(*) This comparatively low figure is due to the fact that the *Midi* rail motor cars are worked only on branch l

French Midi Rys.	Paris-Orleans Rys.	Paris-Lyons-Mediterranean Rys.
3	4	5
4 290	7 812	9 887
1 213	237.5	100.5
1 774	...	...
561	148.5	100.5
2 210	970	265.7
100 — 34.5	2 — 4.25	19 — 4.665
8 830 063	7 374 049	720 000
8 675 331	5 626 801	870 000
1 766 145	4 217 197	...
613 298 909 (weight r. m. c. incl.).	2 944 494 400 (incl. r. m. cars).	218 000 000
2 999 307	2 090 784	600 000
3 273 562	2 185 283	750 000
258 935	...	...
1 668 253 610	2 131 133 700	263 000 000
Yes.	Orleans — Tours.	No.
course 380 km.— Projected 270 km.	Vierzon. — Brive.	...
0: BB. — 10: 2C2. — 6: 2D2.	10	7
0 t. — 57 t. (2 C 2). — 120 t. — 74 t. (Under constr.)	132 t. — 72 t. — 2 D 2.	159 t. — 107.4 t. — 2 C_0+C_0 2
00 H. P. (2 C 2). — 3 400 H. P. (Under constr.)	3 240 kw. at the rim.	5 340 H.P. at the rim.
50 H.P. at the rim. — 12 000 kgr. (Under constr.)	17 600 kgr. —	18 000 kgr. at the rim.
130	195	30
78 t. — B B.	77 t. — BB.	128.2 t. — 103.9 t. — 1 C_0+C_0 1
1 800 H. P.	1 270 kw. at the rim.	2 450 H.P. at the rim.
10 000 kgr. at the rim.	9 900 kgr. —	18 600 kgr. at the rim.
28 r. m. cars — 14 motor vans.	80	0
59 t. — 60 t.	64.5 t.	...
700 H.P. — 700 H.P.	728 kw. at the rim.	...
3 300 kgr. — 6 400 kgr.	5 920 kgr.	...
Nil.	4 locos. with gear ratio altered (shunting hump).	Nil.
...	...	...
...	...	...
...	...	...
65 000 km.	55 154 km.	44 000 km.
25 000 (*) —	52 714 —	...
Pooled.	1, 2 and 3 sets of men.	Pooled.

ying very little traffic.

Questions.	1	French State Rys. 2
48	Are rail motor coaches driven by regular men or are they pooled ?	Pooled.
49	By what number of men are the locomotives manned ?	1 or 2 according to locos.
50	Number of locomotives driven by one man	...
51	By what number of men are the rail motor coaches manned ?	1
52	Total number of men for locomotives and rail motor coaches	142
53	Number of men per locomotor	...
54	Total number of men for the same traffic when worked by steam.	...
55	Number of steam locomotives for covering the same traffic	...
56	Corresponding number of men for steam locomotives	4.4
57	Annual costs of maintenance of the electric locomotives	0.5872 fr. without general charges, lubrication and fixed charges per km. run.
58	Annual costs of maintenance of the rail motor coaches	0.6745 fr. without general charges, lubrication and fixed charges per km. run.
59	Annual costs of maintenance of steam locomotives for an equivalent traffic.	2.64 fr.
60	Percentage of time of service of the available electric locomotives.	80 %
61	Percentage of time of service of the available rail motor coaches.	75 %
62	Percentage of time of service of steam locomotives available	75 %
63	Renewal fund for steam or electric locomotives.	No.
64	Annual sums placed to the credit of the reserve fund	Varying annual credit provided in accounts.
65	Do these sums constitute an amortisation fund or do they carry interest ?	Operating (Breaking up programme).
66	Fuel available for the locomotives	Slack, run of mine, screened, briquettes.
67	Hard coal (anthracite) — price delivered to the railway	No.
	— at the depot	...
	— on the tender	...
68	Soft coal — price delivered to the railway	138 to 148 fr.
	— at the depot	...
	— on the tender	159 to 169 fr.
69	Liquid fuel	No.
70	Price of the various classes of coal at the mine head	...
71	Calorific value per unit of weight	7 000 to 8 000
72	Situation of the collieries	Nord. — Saar. — England.

French Midi Rys.	Paris-Orleans Rys.	Paris-Lyons-Mediterranean Rys.
3	4	5
Pooled.	Pooled.	...
2	2	2
None.	18	0
2 — head guard in place of assistant driver.	1 driver, 1 traffic man.	...
662	381	114
2.34 (stock 1930 : 282).	2	3.1
772	627.5	140
522	354	55
1.7	1.76	2.5
1.14 fr. per train-km., without interest nor amortization.	High speed locos : 1.176 fr. — BB : 1.094 (without interest nor amortization per km. run. 0.909 fr.	0.838 fr. par km. run — without interest nor amortization. ...
2.16 fr. per train-km.	2.22	2
38 %	65 %	55 %
37 %	81 %	...
22 %	78 %	30 %
No.	No.	No.
...	...	...
...	...	...
Briquettes, large screened, run of mine, slack.	Nord, Centre, Aveyron and Tarn mines.	Slack, screened, briquettes, run of mine.
240 fr.	Used mixed.	No.
262.50 fr.	...	...
...	...	...
...	140 fr.	133 to 160 fr.
...	...	173 to 200 fr.
...	158 fr.	178.40 to 205.40 fr.
No.	No.	No.
Briquettes : 118 to 159 fr. Large : 105 to 138 fr. Slack : 118 à 128 fr. Run of mine : 80 fr.	Briquettes : 140 to 180 fr. Large : 129 to 162 fr. Slack : 80 to 130 fr. Run of mine : 106 to 145 fr.	Purchased wagon departure and f. o. b.
6 940 to 7 550	7 727	7 500 to 8 000
system. — Germany. — England.	Nord. — Centre. — England. Germany.	Loire. — Saône et Loire. — England. Germany. — Saar.

Questions.	1	French State Rys. 2
73	Carriage rate per ton and per kilometre	Variable according to railway run over.
74	Average cost per locomotive driver	1 340 fr. per month. — 1 260 fr. (assistant).
	— — driver	...
75	— — assistant	1 025 fr.
76	— — for unskilled labour	860 fr.
77	Available energy, in kilowatt-hours, per annum	Outside gen. stations.
	Maximum available power in kw.	20 000
	Power produced by your generating stations	...
	Power produced by other companies.	...
78	Number of traction substations	13
79	Average distance between substations	6 km.
80	Power, in kw.-h. per annum, required for traction	43 805 591 H. T. at entry of substat.
	Maximum power in kilowatts, required for traction	16 000
81	Power, in kw.-h., consumed per train-kilometre	7.61
82	Power, in kw.-h., consumed per 1 000 tkm. hauled	3.9 — 32.9 (with heating and lighting
83	Price of energy, per kw.-h., at the point of supply to the contact line.	0.517 fr.
84	Price of energy, per kw.-h., on the primary H. T. side of the substations.	0.368 fr.
85	Price of energy, per kw.-h., H. T., at your power stations . . .	0.328 fr.
	Average price of kw.-h. purchased from outside sources	...
114	High tension current for feeding the traction substations	Three-phase, 25 cycles p. s. 15 000 v. Being changed to 50 cycles.
119	Kind of traction current	D. C. 650 v. (3rd rail).
129	Height of the overhead trolley wire, above the running rails . . .	...
130	Minimum distance between the overhead trolley wire and the rolling stock construction gauge	...
131	Minimum distance between the overhead trolley wire and metal structures.	...
146	Minimum distance between the third rail and the rolling stock construction gauge.	0.030 m.
147	Minimum distance between the third rail and metal structures . .	No minimum : pieces of wood inserted.

French Midi Rys.	Paris-Orleans Rys.	Paris-Lyons-Mediterranean Rys.
3	4	5
15 fr., increase 370 % (domestic). slow speed tariff 7.107, increase 370 % + 5 % commercial duty.	Cost price on own system 0.075 per tkm. On other systems, slow speed tariff 7.107.	0.185
25 606 fr.	35 670 fr.	Pay rate per hour: 9.846 fr.
...	...	— 11.299 fr.
19 737 fr.	27 940 fr.	— 7.577 fr.
...	21 430 fr.	— 6.488 fr.
500 000 000	...	Outside gen. stations.
100 000	...	...
340 000 000 (gen. stations).	95 000 000	...
...	120 000 000	...
49	11	6
22 km.	Paris area: 15 km. Outside: 25 km.	Level country: 23 km. Mountains: 12 km.
104 675 000 (leaving substation).	L.-T., entry to substat: 106 500 000	27 000 000
40 000	L. T., — 25 000	8 500
8.84	At motors: 9.1 At substat., L. T.: 11.2	20.4
29.20	At motors: 17.1 At substat., L. T.: 21.	56.3
0.15 fr.	...	0.32 fr., including capital and operating charges.
0.12 fr.	...	0.20 fr., including capital and operating charges.
0.10 fr.	...	0.15 fr. H. T.
...	Additional energy: 0.24 fr. L. T. at entry to substations.	...
Three-phase, 50 cycles p. s. 60 000 v.	Three-phase 50 cycles p. s. 90 000 v.	Three-phase 50 cycles p. s. 42 000 v.
D. C. 1 500 v. (trolley wire).	D. C. 1 500 v. (trolley wire).	D. C. 1 500 v. (3rd rail and overhead contact line as accessory.)
Standard: 6 m. 000 In stations: 5 m. 500 Minimum: 4 m. 650	Standard: 5.500 m. Minimum: 4.600 m. Exceptionally: 4.430 m.	Standard: 6.000 m. Minimum: 4.600 m. Exceptionally: 4.550 m.
0.250 m.	0.200 m.	0.300 m. (exceptionally: 0.250 m.).
0.300 m. (exceptionally 0.200 m.).	0.150 m.	0.200 m.
...	...	0.050 m.
...	...	0.250 m. Except for the insertion of a creosoted or paraffined wood packing.

Questions.	1	Algerian State Rys. 6
1	Total length of the system, in kilometres	...
2	Length of electrified lines, in kilometres	110
3	Length of single track, in kilometres	110
4	Length of double track, in kilometres	...
7	Total length of electrified lines (including secondary lines), in kilom.	137
8	Number and length (in km.) of tunnels electrified	16 — 6
9	Annual train-kilometres (passenger)	...
10	Locomotive-kilometres (passenger)	...
	Rail motor coach-kilometres (passenger)	...
11	Gross ton-kilometres hauled (passenger)	...
12	Annual train-kilometres (goods)	...
13	Locomotive-kilometres (goods)	...
	Rail motor coach-kilometres (goods)	...
14	Gross ton-kilometres hauled (goods)	...
26	Are you carrying out a programme of electrification ?	...
27	Extension of your electrification — to what extent ?	Bône — Duvivier (55 km.).
30	Number of electric locomotives (passenger)	...
31	Total weight and adhesive weight of the most powerful type.—Type.	...
32	Power of the most powerful type, hourly rating	...
33	Tractive effort, hourly rating	...
34	Number of electric locomotives (goods)	30
35	Total weight and adhesive weight of the most powerful type.—Type.	115 — CC.
36	Power of the most powerful type, hourly rating	2 400 H. P. at the rim.
37	Tractive effort, hourly rating	21 000 kgr. —
38	Number of rail motor coaches	...
39	Total weight and adhesive weight of the most powerful type	...
40	Power of the most powerful type, hourly rating	...
41	Tractive effort, hourly rating	...
42	Number of electric shunting locomotives	...
43	Total weight and adhesive weight of the most powerful type.	...
44	Power of the most powerful type, hourly rating	...
45	Tractive effort, hourly rating	...
46	Average annual kilometres run { locomotives	...
	{ rail motor coaches	...
47	Are locomotives driven by regular men or are they pooled?	...
48	Are rail motor coaches driven by regular men or are they pooled ?	...

Morocco Rys. 7	North of Spain Rys. 8	Italian State Rys. 9
573	3 814	16 850
311	386.5	1 645
...	217	835
...	169.5	812
382	716	3 375
2 — 2.2	173 — 53.929	382 — 201.6
1 963 417 (elect. and steam).	3 729 448	14 458 241
832 159	1 930 000	15 414 966
397 752	3 127 641	1 530 831
963 926 300 (elect. and steam).	636 325 497 (trains with rail motor cars counted as 70 %).	Locos. 8 367 096 600 (pass.+goods). R. m. c. 117 995 900
...	1 630 849	8 909 486
...	1 861 363	11 820 887
...	...	...
...	597 957 879	See No. 11.
di el Aidi — Marrakech (190 km.).	...	Yes.
357 km.	...	183+377 km.
5	12	208
70.8 t. — BB.	145 t. — 96 t. — 2 C_0+C_0 2.	1—4—1—94 t. — 67 t.
1 340 H. P.	3 240 H. P. at the rim.	2 200 kw. (shaft).
6 960 kgr.	15 600 kgr. at 56 km./h.	14 000 kgr. at 50 km./h. (rim).
21	56	273
80 t. — B + B.	102 t. — C_0+C_0.	0—5—6 — 77 t.
1 450 H. P.	2 280 H. P. at the rim.	2 000 kw. (shaft).
11 200 kgr.	19 500 kgr. at 31 km./h.	14 000 kgr. at 50 km./h. (rim).
10	38	32
66 t. — B + B.	66 t.	52 t.
700 H. P.	920 H. P.	550 kw.
3 280 kgr.	4 230 kgr. at the rim (50 km./h.).	2 800 kgr. at 60 km./h. (rim).
None.	None.	5
...	...	0—5—0. 63 t.
...	...	1 500 kw. at the shaft.
...	...	7 500 kgr. at 25 km./h. (rim).
886 240 km.	516.27 km. (average).	H. sp. 65 340 — L. sp. 39 057.
419 736 —	80 950 — —	47 833
Pooled.	According to the sections.	Usually 2 sets of men per loco.
Pooled.	Pooled.	2 men.

Questions.	1	Algerian State Rys. 6
49	By what number of men are the locomotives manned ?	...
50	Number of locomotives driven by one man	...
51	By what number of men are the rail motor coaches manned ?	...
52	Total number of men for locomotives and rail motor coaches	...
53	Number of men per locomotor	...
54	Total number of men for the same traffic when worked by steam.	...
55	Number of steam locomotives for covering the same traffic	...
56	Corresponding number of men for steam locomotives	...
57	Annual costs of maintenance of the electric locomotives	...
58	Annual costs of maintenance of the rail motor coaches	...
59	Annual costs of maintenance of steam locomotives for an equivalent traffic.	...
60	Percentage of time of service of the available electric locomotives.	...
61	Percentage of time of service of the available rail motor coaches.	...
62	Percentage of time of service of steam locomotives available	...
63	Renewal fund for steam or electric locomotives.	...
64	Annual sums placed to the credit of the reserve fund	...
65	Do these sums constitute an amortisation fund or do they carry interest ?	...
66	Fuel available for the locomotives	...
67	Hard coal (anthracite) — price delivered to the railway	...
	— — at the depot	...
	— — on the tender	...
68	Soft coal — price delivered to the railway	...
	— — at the depot	...
	— — on the tender	...
69	Liquid fuel	...
70	Price of the various classes of coal at the mine head	...
71	Calorific value per unit of weight	...
72	Situation of the collieries	...
73	Carriage rate per ton and per kilometre	...
74	Average cost per locomotive driver	...
	— — driver	...
75	— — assistant	...
76	— — for unskilled labour	...
77	Available energy, in kilowatt-hours, per annum	...

Morocco Rys. 7	North of Spain Rys. 8	Italian State Rys. 9
driver, 1 assistant or head guard.	2	1 driver and 1 assistant.
...	0	2
1 driver.	1+1 traffic man.	1 driver.
...	227	1 970
...	2.1	3.6
Reduction 20 %.	540	2 425
1 elect. loco. = 2 steam locos.	195	735
...	2.8	3.3
1 fr. 345 per engine-km. without general charges nor lubrication.	0.3085 peseta per train-km.	1.286 lire per loco.-km., not including cleaning nor lubrication, interest and amortisation.
...	...	
...	0.9375 peseta.	1.5886 l., do.
50 to 60 %	Passengers: 47 %. — Goods: 36.3 %.	36 % (max. 44 %).
30 %	32.8 %	...
25 %	Passengers: 29 %. — Goods: 32.2 %.	28.6 %
The reserve fund has no special account for amortisation.	No.	2 % of receipts set aside for purchase of new rolling stock.
...	...	Amortisation in 30 years at 6 %.
...	...	Simple amortisation.
English and French briquettes, large Cardiff.	Slack, cobbles, screened, briquettes.	German coal (Ruhr) and English.
...	No.	...
...	...	...
...	...	...
...	31.15 to 50.25 pesetas.	...
Briquettes: 250 fr. — Large: 210 fr.	57.82 pesetas.	...
...	59.28 pesetas.	...
No.	...	...
...	...	...
7 800 bis 8 000	7 710	7 900
From France or England.	Asturias, Leon, Palencia.	...
Average: 80 fr. per ton.	0.045 peseta.	...
30 000 fr.	8 066 pesetas per year.	60 lires per day.
...	...	...
20 fr. per day (natives).	5 454 pesetas per year.	49 lires per day.
12 to 14 fr. per day (natives).	...	31 lires per day.
Outside gen. stations.	20 000 kw./h. per day of 15 working hours.	...

Questions.	— 1	Algerian State Rys. 6
	Maximum available power in kw.	...
	Power produced by your generating stations	...
	Power produced by other companies.	...
78	Number of traction substations	3
79	Average distance between substations	45 km.
80	Power, in kw.-h. per annum, required for traction	...
	Maximum power in kilowatts, required for traction	...
81	Power, in kw.-h., consumed per train-kilometre	...
82	Power, in kw.-h., consumed per 1 000 tkm. hauled	...
83	Price of energy, per kw.-h., at the point of supply to the contact line.	...
84	Price of energy, per kw.-h., on the primary H. T. side of the substations.	0 fr. 22 (Economic index = 250).
85	Price of energy, per kw.-h., H. T., at your power stations . . .	...
	Average price of kw.-h. purchased from outside sources	...
114	High tension current for feeding the traction substations	3-phase 50 cycles. 90 000 v.
119	Kind of traction current	D. C. 3 000 v. (trolley wire)
129	Height of the overhead trolley wire, above the running rails . . .	Standard : 6.000. Minimum : 4.550.
130	Minimum distance between the overhead trolley wire and the rolling stock construction gauge	0.250 m.
131	Minimum distance between the overhead trolley wire and metal structures.	0.200 m.
146	Minimum distance between the third rail and the rolling stock construction gauge.	...
147	Minimum distance between the third rail and metal structures . .	...

* Paid by Company. Consumption is a little over this figure. Regenerated power has to be taken into account.

Morocco Rys. 7	North of Spain Rys. 8	Italian State Rys. 9
...	2 300, 6 000, 12 000 kw. according to sections.	182 000 kw.
...	...	...
...	...	...
4	16	83
60 km.	23 km.	20 km.
18 440 184	77 633 331 at entry to substation H.T.	376 000 000
...	See nº 77.	140 000
13 579	14.35 *	16
24 to 30	57.88 *	45
0.88	0.0936 peseta.	23 centas.
0.444	0.0796 —	19 —
...	...	15 —
...	...	18 —
3-phase 50 cycles.	3-phase 50 cycles. 21 000 to 31 000 v.	3-phase 16 2/3 cycles. 60 000 v. Except for the latest electrifications.
D. C. 3 000 v. (trolley wire).	D. C. 3 000 v. for Pajares line. 1 500 to 1 650 v. for other lines (trolley wire).	3-phase 16 2/3 cycles. 3 700 v. (trolley wire). Trial on one line, 3-phase, 45 cycles. Trial on a second line, D. C., 3 000 v.
Standard: 6.000 m.	Standard on open line: 5.750 m. (reduced to 5.500 m. on Pajares line and even to 4.650 m. on a section with many tunnels). Standard at level crossings: 6.000 m. Minimum: 4.600 m.	Standard: 5.500 m. In stations: 6.000 m. Minimum: 4.500 m.
0.250 m.	0.300 m.	0.200 m.
0.250 m.	0.150 m.	...
...	...	...
...	...	...

Questions.	— 1	Nord-Milano Ry. 10
1	Total length of the system, in kilometres	300
2	Length of electrified lines, in kilometres	45
3	Length of single track, in kilometres	2.25
4	Length of double track, in kilometres	42.5
7	Total length of electrified lines (including secondary lines), in kilom.	135
8	Number and length (in km.) of tunnels electrified	0
9	Annual train-kilometres (passenger)	691 330
10	Locomotive-kilometres (passenger)	...
	Rail motor coach-kilometres (passenger)	...
11	Gross ton-kilometres hauled (passenger)	...
12	Annual train-kilometres (goods)	78 664
13	Locomotive-kilometres (goods)	...
	Rail motor coach-kilometres (goods)	...
14	Gross ton-kilometres hauled (goods)	...
26	Are you carrying out a programme of electrification ?	...
27	Extension of your electrification — to what extent ?	...
30	Number of electric locomotives (passenger)	6
31	Total weight and adhesive weight of the most powerful type.—Type.	64 t. — B+B.
32	Power of the most powerful type, hourly rating	1 400 H. P. at shaft.
33	Tractive effort, hourly rating	9 000 kgr. at 40 km. h.
34	Number of electric locomotives (goods)	The same.
35	Total weight and adhesive weight of the most powerful type.—Type.	...
36	Power of the most powerful type, hourly rating	...
37	Tractive effort, hourly rating	...
38	Number of rail motor coaches	16
39	Total weight and adhesive weight of the most powerful type	56 t. empty — 62 t. under load.
40	Power of the most powerful type, hourly rating	800 H. P. at shaft.
41	Tractive effort, hourly rating	3 000 kgr. at 55 km./h.
42	Number of electric shunting locomotives	...
43	Total weight and adhesive weight of the most powerful type	...
44	Power of the most powerful type, hourly rating	...
45	Tractive effort, hourly rating	...
46	Average annual kilometres run { locomotives	90 000 km.
	{ rail motor coaches	115 000 —
47	Are locomotives driven by regular men or are they pooled ?	Regular men.
48	Are rail motor coaches driven by regular men or are they pooled ?	Regular men.

Netherlands Rys. 11	Dutch East Indies Rys. 12	Swedish State Rys. 13	Norwegian State Rys. 14
3 701	87		3 467
184	44 — 16.5 — 12.8 — 8 — 5.7		195
0	44		160
184	43		35
461	200		360
0	...		9.5
4 913 816	1 650 000		1 550 000
...	620 000		1 620 000
13 625 263	1 030 000		...
R. m. cars: 817 515 780 Trailers: 563 754 299	220 000 000		...
...	50 000		812 000
...	50 000		1 060 000
...	...		...
...	15 000 000		...
...	...		No.
...	...		2 lines of 20 and 27 km.
...	12		39
...	70 t. — 52 t. — 1 A. AA. A 1.		66.8 t. — o B+B o.
...	1 410 kw. at the rim.		1 400 H. P. at the rim.
...	6 400 kgr. at 65 km./h.		8 700 kgr.
...	1		11
...	52 t. — AA+AA.		136 t. — 102 t. — 1 C+C 1
...	650 kw. at the rim.		2 800 H. P. at the rim.
...	4 000 kgr. at 35 km./h.		20 000 kgr.
148	23		2
63 t.	45 t.		4 300 kgr. — 2 200 kgr.
...	450 H. P.		460 H. P. at the rim.
880 kgr. at the rim.	2 700 kgr. at 45 km./h.		2 900 kgr.
None.	None.		None.
...	...		...
...	...		...
...	...		...
13 625 263	67 000		56 000 km.
...	60 000		...
...	Regular men.		As far as possible 1 man alone.
...	Pooled.		1 man with sometimes a watchman.

No data.

Questions.	— 1	Nord-Milano Ry. 10
49	By what number of men are the locomotives manned ?	4
50	Number of locomotives driven by one man	0
51	By what number of men are the rail motor coaches manned ?	2
52	Total number of men for locomotives and rail motor coaches	34
53	Number of men per locomotor	2.4
54	Total number of men for the same traffic when worked by steam.	...
55	Number of steam locomotives for covering the same traffic	1 elect. loco. = 1.5 to 2 steam locos
56	Corresponding number of men for steam locomotives	...
57	Annual costs of maintenance of the electric locomotives	0.948 lira per useful train-km.
58	Annual costs of maintenance of the rail motor coaches	...
59	Annual costs of maintenance of steam locomotives for an equivalent traffic.	2.77 lire per useful train-km.
60	Percentage of time of service of the available electric locomotives.	...
61	Percentage of time of service of the available rail motor coaches.	...
62	Percentage of time of service of steam locomotives available	...
63	Renewal fund for steam or electric locomotives.	...
64	Annual sums placed to the credit of the reserve fund	...
65	Do these sums constitute an amortisation fund or do they carry interest ?	...
66	Fuel available for the locomotives	...
67	Hard coal (anthracite) — price delivered to the railway	...
	Hard coal (anthracite) — — at the depot	...
	Hard coal (anthracite) — — on the tender	...
68	Soft coal — price delivered to the railway	...
	Soft coal — — at the depot	...
	Soft coal — — on the tender	...
69	Liquid fuel	...
70	Price of the various classes of coal at the mine head	...
71	Calorific value per unit of weight	...
72	Situation of the collieries	...
73	Carriage rate per ton and per kilometre	...
74	Average cost per locomotive driver	...
	— — driver	...
75	— — assistant	...
76	— — for unskilled labour	...

Netherlands Rys. 11	Dutch East Indies Rys. 12	Swedish State Rys. 13	Norwegian State Rys. 14
...	2		...
...	...		...
...	1		...
119	...		...
...	2		...
...	...		...
...	...		...
...	...		0.29 kgr. as a mean, not including shop capital charges.
...	...		...
0.13 fl. per train-km., ithout interest, amortisation, renewal of shops.	...		...
	...		...
...	...		...
90 %	...		...
...	...		...
...	...		...
Steam: 2 1/4 %; . m. cars: 2 1/4%; Motors: 4% of purchase price.	...	No data.	...
Simple amortisation.	...		...
Mixed coal.	...		Coal.
...	...		23 crowns per ton.
...	...		27 —
1 061 fl.	...		28 —
No.	...		17 —
...	...		21 —
...	...		22 —
No.	...		...
...	...		10 to 17.50 crowns per t.(f.o.b.).
7 800	...		7 200 to 7 800
Limburg mines. Westphalia.	...		No mines.
0.016 fl., nett costs.	...		0.04 crown per tkm.
360 fl., not includ. insurance.	...		5 700 crowns per year.
445 fl., not includ. insurance.	...		...
...	...		4 500 crowns per year.
475 to 1 775 fl., not including insurance.	...		...

Questions.		Nord-Milano Ry.
	1	10
77	Available energy, in kilowatt-hours, per annum	...
	Maximum available power in kw.	...
	Power produced by your generating stations	...
	Power produced by other companies.	...
78	Number of traction substations	1
79	Average distance between substations	35 km.
80	Power, in kw.-h. per annum, required for traction	10 000 000 entry to substation.
	Maximum power in kilowatts, required for traction	...
81	Power, in kw.-h., consumed per train-kilometre	7.448 to 9.422
82	Power, in kw.-h., consumed per 1 000 tkm. hauled	...
83	Price of energy, per kw.-h., at the point of supply to the contact line.	...
84	Price of energy, per kw.-h., on the primary H. T. side of the substations.	Using 1 200 h. per half year, 18.8 ct. Using 1 800 h. per half year, 13.9 ct. Over 1 800 h. per half year, 9.3 ct. Zone of integration : 5 minutes. According to use.
85	Price of energy, per kw.-h., H. T., at your power stations . . .	...
	Average price of kw.-h. purchased from outside sources	...
114	High tension current for feeding the traction substations	3-phase. 42 cycles p. s. 23 000 v.
119	Kind of traction current	D. C. 3 000 v. (Trolley wire).
129	Height of the overhead trolley wire, above the running rails . . .	Standard : 5.500 m. In stations : 6.000 m. Minimum : 4.500 m.
130	Minimum distance between the overhead trolley wire and the rolling stock construction gauge	0.200 m.
131	Minimum distance between the overhead trolley wire and metal structures.	0.150 m.
146	Minimum distance between the third rail and the rolling stock construction gauge.	...
147	Minimum distance between the third rail and metal structures . .	...

Netherlands Rys. 11	Dutch East Indies Rys. 12	Swedish State Rys. 13	Norwegian State Rys. 14
Outside gen. stations.	Outside gen. stations.		...
The Hague: 11 000 kw. 15 min. Rotterdam: 2 500 kw. 15 min.	11 000 kw.		...
...	...		...
400 000 measured at power stations.	...		...
14	4		6
7 to 17.5 km.	13 km.		...
...	10 000 000		30 000 000 (at contact line).
Amsterdam: 4 949 The Hague: 7 555 kw. Rotterdam: 2 379 measured at power station. 1 hour.	...		...
10	6		...
35	42.5		...
...	...		...
0.374 fl. (power stations).	0.04 fl.		...
...	...	No data.	...
...	...		...
3-phase, 50 cycles p. s. 5 000, 10 000, 50 000 v.	3-phase, 50 cycles p. s. 70 000 v.		Single-phase 16 2/3 cycles p. s. (15 cycles for Ofot lines). 60 000 v. (80 000 volts for Ofot lines).
D. C. 1 500 v. (Trolley wire).	D. C. 1 500 v. (Trolley wire).		Single-phase p. s. 16 2/3 cycles (15 cycles p. s. for Ofot lines). 15 000 v. Trolley wire.
Standard: 5.50 m. Minimum: 4.86 m.	Standard: 5 m. Maximum: 5.90 m. Minimum: 4.20 m.		Standard: 5.50 to 6 m. Minimum: 4.80 m.
0.210 m.	0.40 m.		0.50 m.
0.150 m.	0.30 m.		0.300 m.
...	...		...
...	...		...

[656. 212.6 & 656. 225]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

XIIth SESSION (CAIRO, 1933).

QUESTION VIII:

Organisation for carrying small consignments of goods and the most suitable methods for their delivery with the least delay. Use and selection of fixed and mechanical transhipping plants.

REPORT No. 3

(America, Great Britain, Dominions and Colonies, China and Japan),

by E. MINSART,

Engineer, Belgian National Railway Company.

Introduction.

The parcels traffic is an important one, not only from a commercial aspect but also from the point of view of working it. It is true that the ratio of the weight carried to the total weight of general goods is rather low (2 to 5 %). The parcels, however, are conveyed at high rates (4 to 5 times those for full wagon loads and even more in some instances) and the corresponding receipts are far from being negligible. Furthermore, road motor services compete very severely with the railways in this field. Consequently the railways have to make special endeavours to meet the needs of the public and, as this result has to be obtained without excessive expenditure, the task is very difficult, particularly so, seeing that the greater part of the traffic is composed of many small consignments to different destinations.

In the countries with which this report deals the situation frequently differs from that usually met with on the European continent, as regards both the terminology used and the methods applied when dealing with parcels traffic.

In Great Britain parcels are carried either by passenger train or by goods train. The expression « parcels traffic » is used for goods carried by passenger train. The goods are usually sent by passenger train when the consignor asks for fast transport and for this service a higher rate is charged. When the weight of the consignment does not exceed 150 to 200 kgr. (330 to 440 lb.) the rates follow a scale applied to small lots and the consignment is sent by goods train. There is consequently only one class of parcels traffic conveyed by goods train.

On the Canadian National Railways the term « parcel » is used to describe an express consignment. The consign-

ments of express parcels are sent by passenger train. The term « shipment » is used when dealing with a consignment of goods and this traffic is sent by ordinary or fast goods train. Here again there is only one class of traffic carried by goods train.

Most of the Companies in the United States of America have an agreement with an express parcels company known as the « Railway Express Company » which undertakes all express parcels traffic. The « parcels » generally do not exceed in weight 50 kgr. (110 lb.) and the traffic is sent exclusively by passenger train. The ordinary parcels traffic includes all consignments to which the rates for less than full truck loads in the standard goods classification are applied and is worked by goods train.

In most other countries by « parcels » is understood consignments sent by passenger train, or in certain cases by express parcels trains and charged accordingly. This is an express traffic although it be considered in certain countries as ordinary parcels traffic for the reason that there is but one class of parcels traffic (by passenger train). On these railways, however, the goods traffic includes consignments offered in quantities less than the truck load, handled and forwarded in conformity with the regulations and rates in force.

The result of the above is that we have to consider 2 classes of parcels traffic, i. e. :

1. Parcels traffic by passenger train, which is known as express parcels traffic on the European continent;

2. Parcels traffic carried by goods trains.

As many points are common to both the express and the ordinary traffic, it has seemed desirable, in order to shorten the report, to treat the two together; when necessary the traffic more particularly in view will be mentioned.

In drawing up this report, the order of the detailed questionnaire submitted to the Railway Companies has been followed.

Preliminary questions.

Parcels handed in for conveyance by fast train are generally forwarded by passenger trains and rated accordingly. In nearly all cases there is a weight limit, varying from 100 to 250 kgr. (220 to 550 lb.) and also in some cases limits as to dimensions and volume. Loading and unloading are carried out by the railway staff. Some railways will not accept inflammable or dangerous materials. One railway system doubles the rates for bulky materials. On others the loading and unloading of goods exceeding the maximum weight are carried out by the consignor and the consignee respectively; this applies especially to fruit, milk, vegetables, and other farm products.

The traffic of ordinary parcels includes all packages, bales, cases, bundles, parts, etc., conveyed under the rates conditions applicable to less than truck loads. None of the replies received mention any limit of weight. In England and Ireland however the goods trains convey small consignments not exceeding 150, and 150 to 200 kgr. (330 and 330 to 440 lb.) in weight and charged according to a scale known as « smalls ».

The express parcels traffic is generally worked by passenger train and the ordinary parcels traffic by goods train.

The traffic is generally sent by the first train available and on most of the railway systems considered the period in which the consignment will be conveyed to destination is not guaranteed; the time taken depends entirely upon the destination. Several Companies point out that the train times are published, and that these give the time in which the consignment will be delivered, these times being regularly kept. The other Companies undertake to give a suitable

service and to convey all consignments within a reasonable period. When the normal period is exceeded or in those cases when the times are published, if these are not kept, the railways is responsible for any loss in value of the goods, without however being obliged to meet claims for other damages.

The reasons which make necessary an organisation which can convey the parcels as quickly as possible are : the obligation falling on the railway as a public service to carry all traffic offered; legal requirements; in certain countries the fast conveyance of perishable materials, but more generally the financial operation of the undertaking and the putting into operation of a fast service with a view to retaining the customers and to meet road competition.

Acceptance of traffic.

Cartage service. — A cartage service exists in many countries in the large towns, either for express traffic only or for both. This service belongs to the companies and is worked by them, or leased to contractors. In the United States of America the whole of the express parcels traffic is worked by the « American Railway Express Company ». This Company organises the collection and the delivery of parcels by motor vehicles, and also their conveyance from one point to another.

Usually the area in which such parcels are collected is laid down. The service is covered by regular turns, fixed so as to bring the goods to the dispatching stations in time for the trains by which they will be sent away. A practice to be mentioned is that of sending the cartage vehicles every day to regular consignors.

One railway points out that in many rural districts whatever the traffic offered may be, there are regular daily services for collecting traffic and delivering it, radiating round a main station, stopping at the small stations in their area and collecting therefrom every parcel handed in for conveyance by passenger train. If the traffic can be conveyed more rapidly thereby, the lorries also deliver to the stations in their area every express parcel that they have been able to collect for dispatch by rail. The ramifications of these collecting and delivering services attached to a main station are being progressively extended and the final objective is to make them into a network covering all the rural districts throughout the part of the country served by the railway and connecting up the towns and villages not served by rail.

Parcels receiving offices. — Receiving offices for goods are provided in different parts of the large cities by many of the railways for the express parcels traffic, and also, though less frequently, for the ordinary goods traffic. The parcels are accepted during hours the offices are open and steps are taken to cart the goods to the railway station at frequent intervals in good time for them to be forwarded by the booked trains. This organisation is a facility provided for the convenience of the public and in certain cases aims at fighting the road competition. It does not offer any advantage as regards the speed of conveyance.

With the same object, certain large centres have town stations connected by rail or by lorry to the central station. These stations enable very close contact to be made with the consignors of goods and the consignees. In the United States the terminal companies operate such terminal stations situated in different parts of certain industrial cities where ordinary consignments for all the railway systems serving the community in question are accepted. The goods are then sent to the forwarding station either by railway or by road. The use of motor lorries is extending rapidly for the reason that they save about 24 hours at the de-

parture end. Under these conditions, the town stations are no different from receiving offices and give the same advantages.

Loading. — Consignments are generally accepted at the goods shed or parcels office and are loaded into wagons by the railway staff. There are exceptions in the case of articles which either by reason of their dimensions or their weight cannot be handled by the station equipment; loading into the wagons then falls upon the consignor. Certain goods, such as fish, fruit, meat, flowers, and farm products, conveyed in large quantities, are loaded directly into the wagons under the supervision of the railway staff. In this case a reduced rate is often applied. The advantage of direct loading lies in the reduction of staff and also avoids claims being made for damages during conveyance and during loading and unloading.

Days on which traffic is accepted. — Express parcels are usually accepted every day for all destinations, Sundays included, with few exceptions. Ordinary traffic is as a rule only accepted on weekdays.

One Company reports that it gave up the practice of the grouping and forwarding consignments for certain destinations on certain fixed days some years ago.

The *Kenya and Uganda Railways and Harbours* accept small parcels for goods trains on certain days only at important centres. The advantages are : reduction in the warehousing charges and in the responsibility of looking after the goods, with a better utilisation of the rolling stock.

Hours at which parcels are accepted. — Express parcels are accepted by certain Companies during the hours the small stations and offices are open and at the large stations during the whole of the 24 hours. The hours during which they are accepted are laid down in most cases. In the small stations parcels traffic is only accepted during certain hours, or whilst the stations are open, or when some clerical staff is on duty, or according to the times the trains are calling.

Ordinary parcels are only accepted during the day, between certain stated hours, with exceptions on Saturday on certain railways.

Receiving formalities. — The railway is obliged in certain countries to weigh the parcels; the consignor does not have to state the weight. If it is stated, the weight is checked unless the consignor (in the United States) has entered into a duly executed contract, in accordance with which the stated weight is accepted, or if periodical checks show that the weights declared by the consignor are exact. In cases where weighing by the railway is not obligatory it is nonetheless general practice for it to be done. A charge for weighing is made by certain companies when this work is done.

The consignor is generally called upon to label each parcel, with certain exceptions (in England especially) for consignments consisting of a large number of parcels sent by one consignor to a single consignee. The labels should give the name and address of the consignor and of the consignee, or the latter alone.

Some companies attach a destination label to each parcel; others do not think it necessary to do so. Destination labels are more generally used for express traffic than for ordinary traffic. Labels of different colours are used to distinguish parcels conveyed carriage forward from those sent carriage paid. Labels bearing the number of the corresponding waybill are also used.

Consignments carriage forward are accepted more generally in the case of ordinary traffic than of express traffic. Perishable or dangerous goods and those the value of which is less than the car-

riage charges are not accepted carriage forward. In the case of all consignments for stations where there is no cashier (United States) carriage must be prepaid at the dispatching station.

The waybills are prepared immediately after the goods have been accepted or are made out after the wagons have been loaded. The charges are paid by stamps on several Companies for consignments up to a certain weight, sent by passenger train; in this case no waybill is used.

The waybills or other papers either actually accompany the goods to destination or are sent in advance by passenger train or by post, if this will make it possible for them to be received before the goods.

The consignor should hand in with the goods a document which may be the waybill properly speaking in the case of certain Companies, or a declaration (bill of lading, shipping order).

In order to accelerate the operations the consignors prepare the waybills in manifold in sufficient number for a copy to be signed and returned to them as an acknowledgement of receipt. If the forwarding note or the loading sheet is used, the original is signed and handed to the consignor, and a duplicate (carbon copy) is retained by the railway and this document is used to show the charges, and in the preparation of the waybill. Certain stations on the Baltimore and Ohio Railroad Company use what is known as fan-fold bills, combining the waybill, advice to the consignee, the acknowledgement of receipt, receipt of payment, etc., all these documents being filled in at one writing by means of carbon paper by the forwarding station. Similar methods are also used by other Companies.

The waybill when handed in by the consignor, or the consignment note, can be used in connection with the operations of loading the goods.

As special measures for simplifying the operations when receiving parcels, we may mention the weighing machines automatically recording the weight and the « agreements as to weighing » to which we referred above.

General organisation for forwarding parcels.

On the railways of the countries with which this report deals, express parcels are conveyed by passenger trains, in the brake vans or luggage vans, provided according to requirements. In certain cases, special parcels trains are run to deal with seasonal traffic. Speed is the first consideration and in most cases the question of the use made of the rolling stock does not arise. Many Companies give a door to door service, either by means of a cartage service, worked by themselves or contracted out, or through an express parcels Company.

The ordinary parcels traffic, although sent by goods trains also requires a fast service.

Speed and regularity are the important factors to be considered in this traffic, but the proper utilisation of the rolling stock should also receive the most careful attention.

Generally speaking every station holds instructions dealing with the loading of wagons for all destinations. A certain number of regular wagons of different classes (according to the destination or destinations of the parcels loaded) are run each day. These *regular* wagons or *scheduled* wagons, are provided according to the traffic and so as to ensure *through* wagons being worked to the greatest possible extent. The most generally applied principle is to load the goods to the point nearest their destination when it is possible to load through to destination.

On the large railway systems there are as a rule not more than two transhipments. This occurs in the case of a consignment collected at an intermediate

station by a pick-up wagon, carried to a suitable transhipment station and conveyed therefrom by a through wagon to the transhipment station near the destination.

Steps have been taken to conciliate the two factors mentioned above : the speed and the utilisation of the rolling stock. Periodical returns are prepared giving the number of wagons forwarded and the average weight conveyed per wagon, for each regular wagon. When the tonnage of a wagon begins to fall the programme is reconsidered; in other cases, the analysis of the reports shows whether a through wagon can be provided.

Loading goods.
Wagons for parcels traffic.

Express parcels are generally loaded as soon as possible, seeing that they are forwarded by the first suitable train. The loading is subordinated to the train departure times and the consignments are grouped together by destination whenever possible. On the *Great Indian Peninsula Railway,* where the parcels are forwarded by special trains known as « parcel expresses » the parcels are loaded at the end of the day, in order to group the consignments according to route. The advantages are : better loading of the wagons, less chance of the parcels going astray, quicker transit, less handling en route. The disadvantages are : congestion of the parcels offices with restricted accommodation and heavy traffic, opportunities for theft, and possibilities of damage to the goods.

Parcels conveyed by goods train are generally loaded into the wagons as soon as possible after they have been handed in by the consignors. The advantages of this arrangement are : the congestion of the reception platforms during the last hours of the day is avoided when the greater part of the goods are received and better use is made of the labour by spreading the loading operations over the longest possible period.

On the *Baltimore and Ohio Railroad,* forwardings by *through* wagons predominate and immediate loading is necessary in order to keep the reception platforms clear for the acceptance of goods. Consignments to be off loaded by the staff of *local* trains should be arranged in the wagons in station order and generally it is not possible to load them in this way until the whole of the goods have been received.

The *South African Railways and Harbours* and the *Kenya and Uganda Railways and Harbours* ordinarily load up at the end of the afternoon. The advantages are : a good use is made of the wagons and the road wagons and trains wisely chosen. In addition the consignments can be loaded in station order according to the route to be followed.

Ordinary parcels are generally forwarded the day received.

Ordinary parcels are not as a rule loaded during the night, nor on Sundays and holidays. This does not interfere with the flow of the traffic as on many of the railways the stations are not open for the reception of goods on Sundays and no traffic is offered. Night loading is considered as unsatisfactory.

There are 4 main classes of wagons conveying traffic in less than full truck loads :

1. pick up wagons;
2. route wagons or distributing wagons;
3. wagons for single destination or through wagons;
4. tranship or through tranship wagons.

The pick up wagons are used to collect consignments along the line and to convey them to the tranship points.

The route wagons or distributor wagons are used to bring the goods to the intermediate stations in a given area.

Single destination wagons contain goods loaded at a station where there is

sufficient traffic for a single station and these wagons are sent through towards this destination.

The tranship wagons contain goods to be sent to a tranship station.

The use made of these classes of wagons varies more or less from one railway system to another. Wagons can be at the same time distributing wagons and pick up wagons; classes 1) and 2) are then combined together under the name of local way cars.

A local way car can be loaded at the original station to a station close to the area to be served, or it can be loaded at a station far away, possibly hundreds of miles, from the area to be served. In this latter case, it is called a transfer car on certain railways.

Single destination wagons can contain goods for one destination alone or, in addition for the place to which it is dispatched, for destinations before or after this point.

The collector wagons and the route wagons are worked in goods trains concurrently with full load wagons. Single destination wagons and through tranship wagons are dispatched as a rule on fast goods trains or on goods trains made up to full load.

On certain railways the waybills are sent with the wagon in which the goods are loaded. In other cases this rule is only applied when the route wagons are in question: with the through wagons a wagon waybill on which is entered the number, destination, tonnage, the waybills properly speaking of the goods being sent beforehand to the unloading point.

There are *regular* or *authorised* or *booked* wagons in each class; there are many hundreds of them each day (4 255 on the *Pennsylvania Railroad*). The regular wagons run every day without any minimum tonnage being specified.

The stations are authorised and encouraged to make up *special, extra,* or *non-scheduled* wagons when the volume of traffic justifies it. These special wagons can be put into any one of the classes given above. They are forwarded on the same trains as the regular wagons.

On many railways, the use of special wagons is left to the forwarding stations. Other systems require a minimum tonnage, but the decision frequently depends upon circumstances such as the direction of the traffic, the destination of the wagons, and the nature of the goods.

The advantages obtained by using special wagons are : manual operations at the tranship stations are made unnecessary, the shunting of the wagons en route is reduced and in addition the traffic is speeded up.

Express parcels are forwarded the same day as received by the first suitable train. Exceptions are allowed by certain Companies when by holding the consignments for a following train, they can get to their destination at a more suitable hour for dealing with them without increasing the delivery period.

The forwarding is sometimes fixed in accordance with the train service shown in the working time tables. In certain cases (*Central Argentine Railway*) as in the case of trains running long distances, the express services are limited to certain stated week days.

Most of the important stations have the necessary facilities for forwarding ordinary parcels the same day as received and they are sent away by the first train by which such parcels are conveyed.

On the *Canadian National Railways* some stations are allowed to hold back the consignment when long distance wagons are being loaded in order to get better loading. On several other railways stations can utilise heavy consignments weighing as much as say 2 500 kgr. (5 500 lb.) as the nucleus for a through wagon or a transhipment-distributing wagon; these wagons are for-

warded the following day, with the total load obtained. The advantages are :

1. the additional day held at the forwarding station, in any case would have been lost at the transhipment point;

2. the additional tonnage collected has gained 24 hours.

The loading of express parcels in the brake vans of the trains (guard's van) is the general practice on many railways. In the United States of America, the express parcels forwarded by the Railway Express Company are loaded in regular parcels wagons of the railway provided according to need, and duplicated by express wagons specially fitted with fixed cupboards. The ordinary parcels are conveyed by goods trains.

As regards the way in which a station decides if it should load a wagon for one designation, the method in use on the *Pennsylvania Railroad* may be described here. Each station has precise instructions indicating into which regular wagon the consignments for each destination are to be loaded. The wagons are marked by a « spot » (situation) number showing the place at which the wagon to be forwarded by the station is to be found. The reference numbers are shown on a diagram of the sidings. One or more employees are responsible for writing the « spot » numbers on the waybill relating to each parcel when handed in by the consignors. If a consignment for a destination involving one tranship amounts to about 3 600 kgr. (8 000 lb.) the « spot » employee will load a *non-authorised* wagon for the destination and mark the forwarding order accordingly. The supposition is made that an additional load will offer itself during the day and will justify with the nucleus of 8 000 lb., loading a through wagon. If however, the additional load expected is not offered, the wagon is forwarded none the less.

The American Companies do not label less than truck load wagons other than those containing inflammable or explosive materials. In England, labels are used to show the receiving stations the number of parcels to be unloaded by them. The *South African Railways and Harbours* use different patterns of wagon labels : one label for wagons loaded to destination and another label for tranship wagons. These last give the names of the different stations for which there are goods in the wagons. In this way the work at the different stations is facilitated, and the label also helps the guard in getting the goods unloaded at the intermediate stops.

The extra work falling on the tranship stations during the periods of heavy parcels traffic is covered by additional staff, or by working extra hours, or during the week end.

Another method is to make a still more careful analysis of the consignments at the originating point in order to group together additional consignments in order to form further through loads, either for a single destination, or for a tranship station serving the destination.

On most of the railways the rates are based on the shortest route; but on some railways the traffic may be diverted to other routes traced out so as to make use of the through wagons running between the tranship stations; the object is to speed up the traffic and to avoid unnecessary handling at the intermediate points.

The parcels are loaded and unloaded by the railway company's staff on most railways. This method is considered to be more profitable than that of employing contractors to do this work.

The supervision is better and the parcels are handled more rapidly and at less cost. Two Companies load and unload parcels in the big stations with labour supplied by contractors, but

under the supervision of the station staff.

Wooden cases are used by the American Express Company on all the lines in the United States, to group together the consignments of small parcels. This method makes the handling of the parcels cheaper and diminishes the risk of losses and damage. Several Companies are making use of « containers » in the less than full car load traffic. On different parts of the *Pennsylvania Railroad* a service of « containers » has been organised as between stations, for the conveyance of parcels. The inside dimensions and the loading capacity of these steel containers are the following :

Length, 2 m. 10 (6 ft. 11 in.)
Width, 2 m. 72 (8 ft. 11 in.)
Height, 2 m. 60 (7 ft. 6 in.)
Capacity, 5 436 kgr. (12 000 lb.)
Tare weight, 1 359 kgr. (3 000 lb.)

Figure 1, dealing with the containers' transhipment station at South Kearny shows the type of containers in use.

The containers are loaded in sets of five on a flat wagon. At the loading stations there are five containers loaded on each wagon, each for a certain destination. This wagon with five containers is worked to a transhipment station into which other wagons also work, each wagon with its five containers having been forwarded from other centres; the containers are regrouped in each wagon and each wagon leaves the transhipment station with five containers for the same destination.

This method of dealing with the less than truck load traffic gets the traffic away more quickly than the usual method of using covered wagons : it saves the cost of handling at the transhipment points, avoids running wagons lightly loaded and makes it possible to load directly to destination in smaller quantities than would be possible to do economically by loading into covered wagons. The sole drawback is that individual consignments which exceed the capacity of the container have to be forwarded in wagons and this in certain cases may delay the goods because the wagon must be sent through a transhipment station.

In important towns served by several railway stations, the arrival of goods forwarded by the different lines is speeded up by forming through wagons for the different goods stations.

The same method applies in the opposite direction for traffic being loaded away. Some Companies use motor lorries to exchange goods between the different stations in order to accelerate the despatches and the arrivals by the different routes. These lorries generally make regular trips and also convey special traffic as needed.

When there are several small stations and one large central station in the same area, the traffic for the small stations is worked into the large station, and carted by lorries to the destination station.

The cartage service is operated by the Company or by a reliable firm on its behalf, on the basis, for example, of a fixed price per ton.

Special measures are not often necessary to speed up the conveyance of parcels over short distances. Forwarding by passenger trains which ordinarily are not allowed to be used for this service, is one method of which use is sometimes made.

The road competition is also fought by organising the train service so as to be able to work the goods forward by night.

In England, motor vehicles are used to cover the first and last stages of the working, the intermediate parts being done by rail. The *Great Northern* Railway (Ireland) considers it necessary in certain cases to convey the short-distance traffic direct by motor lorries, and it is possible that this method of operation will be extended further in the future. The *Federated Malay States* Railways use motor lorries for conveyance between stations not directly connected by railway.

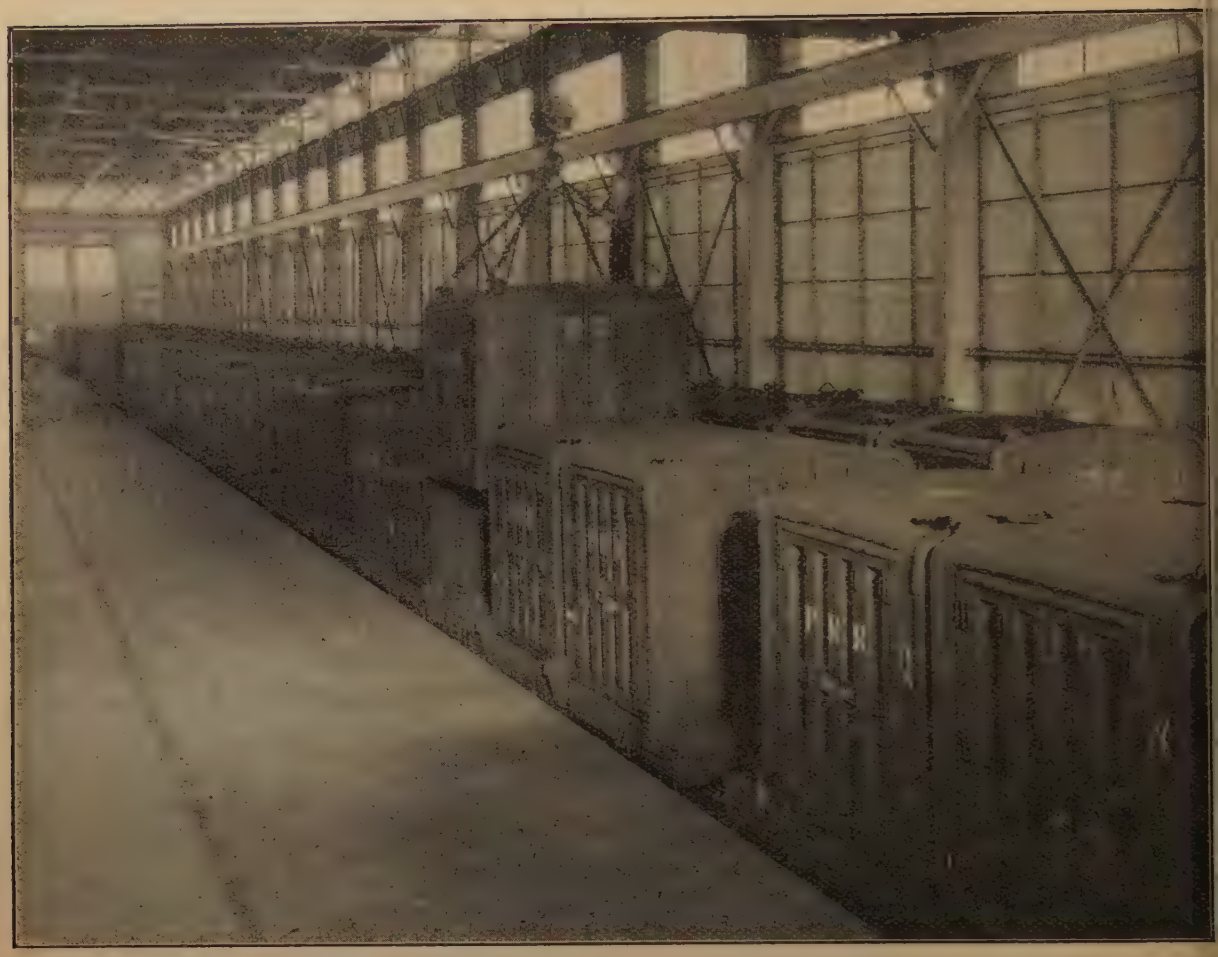


Fig. 1. — Containers transhipment station at South Kearny, Pennsylvania Railroad (U. S. A.).

Motor lorries are employed by one Company in station-to-station service along the line in replacement of the local trains that were formerly worked in that area.

Trains by which parcels wagons are forwarded.

Express parcels traffic. — In the countries dealt with in this report, express parcels are sent by passenger trains, though not by all passenger trains, and by mixed trains. The trains that are excepted are the suburban trains, as these follow one another at close intervals, and certain « Limited Expresses ». On many railways the parcels are conveyed in express wagons and all passengers trains do not convey such wagons, the volume of the traffic not necessitating this measure. In cases in which the number of wagons is such that the allowed weight

of a passenger train is exceeded, special trains are formed for the express parcels traffic, and are run at passenger train speed. Some Railways work regular parcels trains and newspaper trains, on which passengers are not carried, but are solely reserved for the traffic for which they were provided. These trains are run at passenger train speed (England) or if parcels trains, at a slightly lower speed.

Ordinary parcels traffic. — Practically speaking, trains for conveying parcels traffic only, are run nowhere. The through goods and local goods trains convey at one and the same time traffic forwarded in full and less than full car loads. The parcels traffic is generally not heavy enough to justify special parcels trains involving additional expenditure. Parcels vans from one terminal station to another are attached to through trains.

The local trains are not often run at night, as at most of the small stations no staff is on duty during the night. When possible, some of the local trains conveying parcels traffic are run during the night. This is done to avoid interference with the passenger trains during the day and to get an accelerated service for both the car load and less than car load traffics.

The speed varies within wide limits according as it is a case of branch lines or main lines and of local trains or through trains, from 9 miles per hour (local trains) to 40 and 50 miles an hour (through trains).

The wagons containing parcels are preferably grouped near the engine to avoid shunting in the marshalling yards. Some railways place them in the rear of the train when there are platforms alongside the main lines in the stations at which the train stops.

The men working on the trains conveying parcels traffic are not as a rule specialised; they also deal with other trains.

Specialisation is sometimes introduced in the case of the staff of local goods trains.

The staff of the local trains are provided in most cases with a waybill for each consignment. The through wagons are treated in the same way, or are accompanied by a wagon waybill only giving the destination of the wagon and a summary of the true waybills.

Loading and unloading at the intermediate stations is carried out by the train staff or by the station staff or in most instances by both.

The services are generally combined in such a way as to make it unnecessary for any parcels to be transferred as between train employees.

The consignments are handed over by the train staff to the destination station staff on many of the main railways by simply checking the parcels against the waybills which have been sent in, and this applies to all goods. Special arrangements are made by certain railways for handing over « declared value » parcels, or the like, for which a signature is required.

The actual handing over of the parcels in the stations has been simplified by doing away with all unnecessary writing and the parcels for intermediate stations are grouped together and loaded in the wagons in station order, in order to facilitate quick unloading.

Transhipment at intermediate stations.

Express parcels alone are transhipped at intermediate stations while the trains are stopped; most often these are parcels which have to be transferred from the main line trains to the branch line trains and vice-versa. The work is carried out by the station staff.

Tranship stations.

Tranship stations which must not be confounded with the shunting yards, do

not as a rule work 24 hours a day. The working hours are from 7 or 8 a.m. to 4 or 5 p.m. In certain important stations, the work commences early in the morning, or finishes late in the evening, the hours of duty of the men being spread over accordingly. These periods of duty are based on the expected times of arrival of the trains during the night and the first hours of the morning. Night work is done at certain stations where the wagons arrive late in the day. It is not thought to be economical to carry out the transhipment of goods during the night. Sometimes the work is carried on with a reduced staff during Sundays and holidays. The express parcels traffic is transhipped on week days and on Sundays.

The transhipment of goods is carried out by the railway staff and not by contractors. (Express parcels handed over to the American Express Parcels Company are transhipped by its own men who are entirely employed by their own company in the large stations. In the small stations, a railway employee working part of his time for the Express Company handles the Company's transhipments.)

The men are grouped into gangs, one gang usually consisting of three men, a checker and two loaders. In addition there is a small number of loaders who look after the loading of the goods into the wagons on the departure side, and help in the work.

A head foreman and one or more foremen supervise the work.

Some railways have a premium system applicable to the transhipment of goods. The men working in a gang receive a premium in addition to their regular wages when they have handled more than a fixed number of tons. The premium is based upon actual figures recorded giving the tonnage transhipped per man per hour at each station concerned, and the wages paid at the normal rate.

The premium is applied to all tonnage transhipped above the fixed minimum.

There are mainly two types of tranship stations:

1. a certain number of tracks, up to 8 or 10 are arranged with a platform between two pairs of tracks (three platforms for eight tracks). In addition there are one or two outside platforms for goods arriving and leaving, when the station is also a goods station;

2. one single large platform is provided with four or five tracks on each side.

The platforms are lighted almost always by overhead electric lamps and the inside of the wagons is lighted if need be by portable electric lights with flexible leads from plugging-in points placed at suitable positions.

Most of the Companies work on the principle of transhipping the goods from one wagon into another, without offloading the contents on to the platforms. It is not considered advisable from the point of view of economy and quickness of unloading, to unload the goods from the wagons onto the platforms, and subsequently to reload them therefrom. By transferring the parcels directly from wagon to wagon, the platforms are kept clear so that the goods may be handled rapidly.

According to information supplied by the *South African Railways and Harbours*, the other method (to offload the parcels onto the platforms and then regroup them for reloading) is to be preferred in order to get : *a*) more through loads; *b*) better tonnage per wagon. The first method tends to increase the station loadings to tranship stations and thereby to slow down the conveyance. In addition, at the tranship stations, the wagons are received without the parcels having been sorted.

The tranship stations forward all classes of wagons (route wagons, through wagons, tranship wagons); the

wagons are sent away once a day at the end of the day's work or sometimes twice a day according to the nature of the operations.

The number of times the wagons are brought to the platforms depends upon the hour of arrival of the wagon at the station, of the speed of unloading, and the local conditions.

It is customary however, to place all the available wagons at the station before the loaders come on duty. The wagons arriving later in the day have to be placed at the ends of the tracks, or, in some stations, a second shunt is made during the mid-day hour.

The usual method employed to bring the wagons to the platforms and take away the loaded and empty wagons, is to use shunting engines.

The method of working used on the *Delaware and Hudson* Railroad is the following. The station is of the first type mentioned above; it has 8 tracks numbered 1 to 8. The loaded wagons are placed on the outside lines 1 and 2, 7 and 8.

The empty wagons stand on the inside lines numbered 3, 4, 5 and 6.

At the beginning of the day's work, all the gangs are set to work on the wagons on tracks 1 and 2, and the contents are transferred into the wagons on tracks 3, 4, 5, and 6.

When the wagons on tracks 1 and 2 have been dealt with, the gangs are sent to tracks 7 and 8 and work in the same way, transhipping the contents of the wagons on the outside tracks into wagons on the inside tracks, whilst the shunting engine removes the empty wagons or reloaded wagons from tracks 1 and 2, and fills up these tracks with further loaded wagons.

The gang continues to work alternatively on tracks 1 and 2, 7 and 8, and again on 1 and 2, and so on. The shunting engine removes the wagons dealt with from the two outside tracks while work continues on the two other outside tracks. This method makes it possible to carry out the transhipment work without interruption.

The method of the *Reading Company* (second type of station) consists in placing the wagons as soon as they are received or soon after, on the tracks known as the circulation lines.

These lines are the ones running along the centre platform on each side. From these wagons the goods are transhipped into the wagons placed on the other tracks on which tracks are to be found the empty wagons for the different destinations following a standard programme, the same place being assigned each day to each destination.

In many transhipment stations care is taken to load the wagons in the order in which they will be formed in the trains in order to reduce operations in the shunting yard. These stations work to a programme drawn up beforehand. The wagons put alongside the platform are designated by a situation number giving the track and the position of the wagon on the track. The employee responsible for the clerical work enters on each waybill the position number of the wagon in which the goods are to be loaded. As soon as the waybills of an inwards wagon have been entered up they are handed over to the gang who then have simply to tranship the goods in the wagons in accordance with the numbers inscribed on the waybills.

The classification clerk or the foreman decide into which wagon each consignment is to be loaded and this work is done in accordance with the waybills. From time to time during the day through wagons may be loaded, the decision to do so being governed by the volume of traffic and other considerations of a general order. Large consignments are used to form the nuclei round which to load supplementary through wagons to single destinations, or to another transhipment station.

The time consignments of parcels re-

main at a transhipment station varies considerably. An endeavour is made to get the traffic away the day it arrives. It is generally accepted that the transhipment of a consignment delays the delivery of the goods by one day.

Unloading parcels. Advice of arrival.

As a general rule at the intermediate stations the parcels are offloaded during the time the train stops. Two railways report that they have given up the practice of working wagons with loads for two stations or wagons to be detached at each station with the inevitable delay it causes. The stations are not authorised to withold wagons.

It is found better to use an additional wagon which can be detached and in which the available space remaining is used for parcels for small stations and for parcels to be unloaded en route.

At terminal stations, express parcels are unloaded immediately.

The ordinary parcels arriving during the night or the early hours of the morning are placed in the goods shed for delivery about 7 or 8 a. m.; the wagons arriving later are unloaded before midday.

Preference is given to perishable goods.

The unloading of ordinary parcels is not usually done on Sundays and holidays.

The goods are unloaded in most cases in accordance with the waybills; no lists are drawn up. In some transhipment stations lists are drawn up beforehand for the use of the men who have to deal with the wagons on arrival. In the large stations the waybills are frequently received before the wagons arrive; the invoices and arrival advice notes are prepared beforehand and one carbon paper copy of the invoice is used for unloading purposes. The *Pennsylvania* Railroad employs a combined form which includes the waybill, the invoice, the receipt, the arrival advice note, a copy of the waybill and a copy of the invoice; the form is filled up at the forwarding station. The four first documents are sent direct to the agent at the destination station if the consignment is sent in a through wagon; the waybill accompanies the goods if these are to be transhipped.

The consignees are advised by an arrival advice note sent by post, by porter or by telephone. The advice is not sent in the case of carted goods. In some countries (*Argentine*) no official advice is sent, the consignor receiving a copy of the waybill which he is expected to send on to the consignee.

Arrival advice notices are sent as soon as possible after the arrival of the wagons, or after the parcels have been unloaded.

At stations where there is a cartage service, a signature is required on the carman's parcel delivery sheet for every consignment delivered to the consignee; when the latter takes delivery at the station his signature is required on the invoice.

A large proportion of the parcels is delivered on the day of arrival, this proportion being 70 % in the large cities with a regular cartage service. In most cases the remainder is delivered the next day.

Certain Companies have concluded arrangements with consignee firms who have vehicles available at the goods sheds to remove their parcels immediately they are off loaded. As another way of speeding up operations, some consignees have an accredited carting agent to look after their goods and all the invoices for the firms dealt with by one carting agent are grouped together ready to be handed to the carman when he presents himself.

A certain free period is allowed to the consignee by many of the Companies, in which to remove his goods from the

unloading platforms. After this period has expired the Company reserves the right to levy warehouse charges.

Many Companies have, if only in the large cities, a cartage service, for delivering parcels to the consignees, organised on the same lines as that for collecting parcels from the consignors.

Contracts are also entered into with cartage agents to collect and deliver goods to domicile. These measures are taken to meet road competition.

Parcels traffic from or to private sidings.

Certain Companies only undertake to work traffic on private sidings in full truck loads. On many railways, the owners of private sidings can receive and despatch parcels traffic subject to the condition of a certain minimum weight per wagon; this minimum limit of weight varies considerably; it depends in some cases upon the class of goods conveyed and upon the district in which the firm's premises are situated. When the load is less than the minimum stipulated, an additional charge per wagon is made above the normal rate.

The goods in these wagons are checked in the goods stations under which the private siding comes or at a given tranship station.

Checking parcels traffic.

The parcels are not generally checked in any way during conveyance : no record is made during their journey. These measures are considered as unnecessary; the traffic can move freely without any hindrance.

Fixed mechanical equipment for handling parcels traffic.

Two- and four-wheeled trucks are the two appliances most used in the despatching and intermediate stations. Two wheeled hand trucks with nose pieces are also used.

At the tranship stations, and in goods stations, hand trucks predominate. In some cases electric or petrol tractors with four-wheeled trailers are used with advantage. Hand trucking is generally the most economical. Tractors and trailers are used to do the work when the length of the run justifies it. Some tractors are built so that they can be run into the wagons; usually, they do not enter them, but take the four-wheeled trucks to the door of the wagon into which the trucks are then pushed by hand.

To manipulate heavy loads, some companies use fixed or travelling hand-operated cranes and also platform lift trucks.

Steel containers are used by the *Pennsylvania Railroad* (see page 1786). The cost of the transhipment at the exchange station is approximately ($ 0.25) per container.

When two-wheeled hand trucks are used at the forwarding, transhipping and destination stations for handling consignments, the cost is from $ 0.50 to $ 0.80 per ton.

The average capacity of the containers is 6 tons.

The average load is about 3 tons per container and at the average approximate price of $ 0.80 per ton, the cost of hauling the parcels by hand would amount to $ 2.40, which must be compared with the price of $ 0.25 per container when handled by overhead crane.

Summary.

The following points appear to be the ones on which the discussion by the third section of the Congress can be based :

1. Carting services in the large towns, for the collection and delivery of parcels, owned and operated by the railways or their concessionaires, are to be recommended. The formalities for accepting and delivering goods should be reduced as much as possible.

2. Parcels receiving offices can be organised in the large towns for the convenience of the Public and to meet road competition.

3. Ordinary parcels traffic should be accepted every day, Sundays excepted, for all destinations.

Loading and unloading by the consignor and the consignee respectively, is recommended in the case of certain traffics, when if need be, a reduced scale of rates can de applied.

4. Speed is the prime consideration in organising the parcels traffic. The utilisation of the rolling stock should also be considered attentively. The two factors can be conciliated by a periodical examination of the returns showing the average weight carried per wagon for each regular wagon.

5. The general rule is to forward the consignments the same day that they are received (ordinary traffic).

It is recommended that consignments be loaded into wagons as soon as possible after being handed over by the consignors.

6. From several points of view, it is an advantage to provide *special* wagons. The condition of minimum tonnage, when laid down, should only be applied with some tolerance, and after taking into account the circumstances such as the direction of the traffic, the destination of the wagons, and the nature of the goods.

7. The competition of the road motor transport can be met by using road motor vehicles at both ends of the rail journey and by conveying short-distance traffic by road direct.

8. It is recommended that goods trains including local trains be run during the night when possible in order to prevent mixing them up with passenger trains during the day, and to obtain a faster service for both full truck load traffic and parcels traffic.

9. The best method at the tranship stations consists in transhipping the goods from wagon to wagon, without offloading onto the platform. The work should be organised as far as possible so that it is continuous. Many tranship stations work to a programme drawn up beforehand, and every effort is made to load the wagons placed according to the order of formation of the train.

10. It is generally considered unnecessary to check the parcels during transit; no entry is recorded between the points of origin and destination.

Namur (Belgium), April 1932.

[625. 61 (0]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION.

XII[th] SESSION (CAIRO, 1933).

QUESTION XII :

Co-ordination of operation as between heavy and light railways.

REPORT No. 2

(All countries, except the Continent of Europe),

by Mohamed SOBHI ISHAK Effendi,

Inspector and Secretary, Light Railway Commission, Egypt.

The present report sums up the replies received from fourteen Administrations. As the replies have been — generally speaking — very brief and not very precise, we have not been able to treat the subject in as great detail as we would have wished.

Most of the replies received relate to cases in which the main line railway and the light railway are either managed by one and the same administration or are under the control of the Government. The result is that in such cases the relations between the two systems differ from those which are found where the two organisations are completely independent one of the other.

Among the railways who have replied to the questionnaire we sent them, we have in the first case the South African Railways, the Nigerian Railways, the Morocco Railways, the French West African Railways, the Algerian lines of the Paris-Lyons-Mediterranean Railways, the Ceylon Government Railways, the Dutch East Indies Railways, the Great Indian Peninsula Railway, the Buenos Ayres Southern Railway, the New South Wales Government Railways and, in the second case, the English Railways, the Irish Railways, the Egyptian Railways and the Corean Railways.

I. — Construction. — Rolling stock.

The conditions under which the coordination between the main line system and the light railway system is carried out depends upon circumstances of considerable diversity. Such are: the object for which the light railway was constructed, the gauge adopted for its track, the geographical situation of the railway systems in relation to one another, the nature of the districts served, the type of rolling stock used on each of the railways, the degree of co-operation local circumstances make possible, the degree

of control exercised by the public authorities, and finally the presence in the district of other competing methods of transport (water, road motor services).

The light railways meet various objects: they act as feeders to the main line system, by bringing to it traffic from regions that are either thinly populated or little developed economically, or they act as penetration railways in order to facilitate the development of agriculture; they may also be used to connect with the standard gauge railway particular places, such as manufacturing centres or largely attended markets. They are generally built to a narrower gauge than that on the main line system.

The use by the light railways of a standard or narrow gauge depends above all on reasons of economy, the gauge adopted being determined by the smaller traffic expected, the doubt as to the result that will be obtained, by the kind of traffic (passengers only for example), by the facilities with which the line can be moved to follow, for example, the movement of the agricultural industry (Buenos Ayres Great Southern Railway).

In some quite special cases the use of a narrow gauge has been due to political reasons (this was the case in Morocco where owing to the Algesiras Convention it would have been possible to build a railway to standard gauge at that epoch only with the financial participation of Germany, which would not have worked in with the strategical reason for the system.

Certain railway systems have found that in spite of the economies in the cost of construction, narrow gauge lines have certain drawbacks — additional operating costs owing to transhipment, impossibility of distributing the rolling stock, greater number of train journeys owing to the low capacity of the trains, lower speeds, larger staff and high repairs cost — which can more than make up for such economies and cause the Companies to decide not to build this sort of line in future (South African, Dutch East Indies, and Morocco Railways). The disadvantages mentioned above have been accentuated by the competition of road motor vehicles.

In Egypt certain factors additional to those which justified the construction of light railways make them still more necessary : the construction and maintenance in good order of roads which would enable a road motor vehicle service to take away traffic from the railway are so expensive, during the wet season, that the railway becomes an indisputable necessity.

Nearly everywhere the light railways are arranged transversely to the standard gauge line and act as feeder lines; there is therefore no competition between the two systems. It is exceptional for them to serve the same district; in Egypt where such a case does occur it has been agreed that the traffic shall be divided in such a way that part of the short-distance traffic shall go by light railway and the whole of the long distance traffic by the standard gauge system. The systems are divided in sections separated by tributaries of the Nile. Where both systems run alongside one another a standard rate based upon the rates of the main line system and upon the shortest distance is applied. In Morocco the duplication of the two systems is gradually disappearing.

Rolling stock can only be exchanged between the two systems in cases where the light railway has the same gauge as the main line system; in this latter case, it may however be impossible to make such exchange, especially in the case of the locomotives, owing to the permanent way structures or the track on the light railway being insufficiently strong.

The gauges of the main line and light railways on the different systems are as follows:

RAILWAYS.	Main lines.	Secondary lines.
British Railways	4′ 8 1/2″	Varies between 4′ 8 1/2″ and 2′
County Donegal Rys. (Ireland) . .	5′ 3″	3′
South African Rys.	3′ 6″	2′
Nigerian Railways	3′ 6″	2′ 6″
Ceylon Government Rys	5′ 6″	2′ 6″
French West African Rys	3′ 3 3/8″	2′
Morocco Railways	4′ 8 1/2″	2′
Egyptian Railways.	4′ 8 1/2″	2′ 5 1/2″
Buenos Ayres Great Southern Ry. .	5′ 6″	2″
New South Wales Government Rys.	Same gauge.	

The light railways are generally equipped to carry the same traffic as the main lines; the only exceptions are very heavy or bulky loads; in exceptional cases certain kinds of traffic are not conveyed: such is the case on the French West African Railways, where neither animals nor vehicles can be carried owing to the lack of suitable unloading platforms.

It is only in exceptional cases that traffic between two given points can be carried by two different systems; in Ireland this situation arises through the regime of free competition; in Egypt, where the same case arises, a common system of rates has been introduced. In Morocco this situation is gradually disappearing as the standard gauge is substituted for the narrow gauge.

The case of two systems separated by a canal is extremely rare; it is only found in Western Africa and Egypt; in these cases the goods are transhipped by hand.

II. — Operation. — Rates.

In many cases no maximum period is fixed in which the goods must be conveyed over the two systems, or even over one of them alone. Everything is done however to reduce this time to a minimum, especially where road competition is feared.

On the Morocco Railways a maximum period is fixed. In West Africa this period is for the standard gauge system 1 day per 50 km. (31 miles) or fraction thereof, plus two free days at the loading end and one day at the arrival end, for loading, making up trains, etc.; in the case of goods from the ports, an additional period of 4 days is allowed in the place of 2. On the light railway delivery should be made on the day following that on which the goods are transferred to it. In Corea the consignee should ask for his goods to be delivered within two days of the receipt of the arrival advice note.

As regards the rates various methods have been applied: in certain cases the rates and carriage conditions are prepared freely by agreement between the two railways; in other cases they are fixed by the Government or an official organisation, or at least are subject to its approval; finally in others by the fact that the light railway belongs to the main line system the rates and conditions are the same on the two railway systems.

From the replies received it is not possible to determine upon what basis the agreements in force are based. As a general rule, as there is no competition between the two systems, no steps have been taken to prevent traffic which normally should go to the standard gauge being worked by the light railway system. In cases where such competition is possible, minimum rates are imposed on the light railway (Great Indian Peninsula, Egypt), or the traffic is divided in certain proportions, the same rates — based upon the shortest distance — being applied between two points common to the two systems.

All the stations of one of the two systems accept traffic destined to each of the stations of the other system; the only exception to this rule is for stations at which there is no permanent staff.

Certain light railways do not insure goods handed in for conveyance; those who do apply such insurance over the whole distance, with special rates on each of the light railway and the standard gauge systems, for the respective distances conveyed on each of these systems. In England the insurance conditions are the same on the light railways as on the others. The conveyance of goods that have been insured is subject to special regulations and the goods are classified according to a special scale of rates.

The consignor is required to make a true declaration of the nature of the goods and their value. Certain parcels cannot be insured unless they are sent by passenger train. The company accepting the goods insured reserves the right to make sure that the goods truly correspond to the declaration made and that they are properly packed; the receiving company reserves the right to inspect the insured goods on unpacking. Articles of great value are not accepted for conveyance except on receipt of a written notice 24 hours beforehand so as to enable the railway company to take special safety measures for dealing with the traffic.

The carriage charges are fixed and collected in some cases by the sending station and in others by the receiving station. On certain systems the method of conveyance — carriage paid or carriage forward — decides at which station the operations in question shall be carried out.

The charges include, in addition to carriage charges, station charges, both at the sending and the arrival stations, loading, unloading and transhipment. In New South Wales certain kinds of goods are transported at rates which include loading and unloading, while goods in a lower class have to be loaded and unloaded by the consignor and consignee; transhipping, where necessary, is done at the cost of the railway. On the Buenos Ayres Great Southern Railway the carriage charges and the supplementary charges are calculated separately.

With one exception, the replies received do not show upon what basis the accessory costs given in the rates are based; the Great Indian Peninsula Railway alone reports that these charges are based on the expenditure involved in assuring the traffic.

Station charges are at the charge of the consignor or consignee according to the conditions under which the goods are carried (carriage paid or carriage forward). These costs are paid, according to the railway, either by the despatching company who supplied the wagons, or by the two railways. In this latter case the division of charges is made according to the particular rates of each of the railways; the sending station charges are included in the receipts of the sending system, the station charges of the receiving station in those of the receiving railway system.

Joint stations are provided at the junction of the light railway with the main line railway in those cases when

the two systems have different gauges. In most cases these stations are provided with tranship stages with the standard gauge on one side and the narrow gauge on the other; the provision of these platforms makes it possible to tranship general goods in full wagon loads. In other cases transhipment is directly from wagon to wagon, on two parallel tracks of the different gauges. The transhipment is made by hand or with the help of cranes.

All operations in the joint stations are carried out either by joint staff of the two railway systems, or by the staff of the two railway systems at the same time, or by staff belonging to one of the two systems alone; in the latter case such staff belongs sometimes to the standard gauge system, sometimes to the light railway. On the Buenos Ayres Great Southern Railway this transhipment is carried out by special gangs at the cost of the consignee. In most cases the responsibility of the sending company ends as soon as the transhipment has taken place, and the receiving system has taken delivery. In some cases, however, the responsibility is divided between the two systems and does not end until the goods have been handed over to the consignee.

If damage occurs en route the compensation to be paid is determined either by the railway system responsible or by the receiving system alone, or by the two systems together. Damages found when transhipping are noted and agreed by the staff of the two systems.

In Corea when it is not possible to decide which system is responsible the claim is distributed between the two in proportion to the length or to the capital of each of the two.

Most of the light railway systems consulted are authorised, owing to road competition, to set up road motor services; generally this authorisation has to be granted by the Government. In Egypt the State Railways have also added a river service. These services can convey passengers and also goods. In this case they act as feeder lines to the railways, and cannot be set up to connect two places already served by railway. In England and in Egypt the authorisation to operate motor services is only given to standard gauge railways. On the Algerian lines of the Paris, Lyons and Mediterranean Railways, the road motor auxiliary services are not managed directly by the railway company but by subsidiaries. The contract drawn up by the railway system and accepted by the contractor must be submitted to the competent higher authority for approval. Road services are there considered as services which are distinct from the railway and have their own scale of charges.

List of questions sent to the Railway Administrations.

A. — Inception. — Lines. — Equipment.

1. — What was the determining factor which justified the decision in favour of a light railway system in the region in which it is situated? In other words why was a standard gauge system not provided?

2. — Does this reason still exist?

3. — From the geographical point of view, does the light railway system run in parallel with the standard gauge system or transversally thereto?

4. — Is the gauge the same on the two systems, so as to enable their rolling stock to be interchanged?

5. — Is the light railway system so equipped that all classes of traffic can be carried (just as on the standard gauge)?

6. — Are there places which are

served by the two systems so that it is in practice possible to send goods by either one or the other system ?

In this case, please give the reasons for the duplicated railway service.

7. — If the two systems are separated by a canal, what method for the transfer of traffic is used in practice?

8. — Are the two systems (or one of them alone) limited — and that by law — to a maximum time within which the goods must be delivered at destination?

In this event, what are the regulations?

B. — Forwarding of goods.

a) *Regulations and rates.*

1. — Are the agreements (rates, carriage conditions) under which the two systems work (as regards exchange traffic) the result of mutual agreement (freely concluded) or have they been made obligatory by virtue of laws or regulations issued by the public authorities ?

2. — What in fact are the bases of the existing agreements?

Do they endeavour to avoid competition from the light railways for traffic which normally should be carried by the standard gauge?

3. — If this be so, what, in detail, are the measures taken to this end?

As example :

If two places are at the same time served by the two systems, can the light railway — in the case in which the distance is the same by the two systems — carry the same goods at a lower rate than that of the standard gauge system ?

Same question for the case in which the distance by the light railway is shorter than by the standard gauge line?

4. — Are all stations on one system permitted to accept goods for all the stations on the other system, or is this limited to certain stations?

In this case, what is the reason for this limitation?

5. — If the loading system is allowed to insure goods, can it effect insurances over the whole journey, that is to say even over part of the other system ?

In this case, should it apply its own regulations to the whole journey, or should it apply those of the receiving system to the mileage which concerns the latter?

What in short is the practice in use as regards the insurance of goods interchanged?

b) *Interchange of goods (that is to say sent from one system to another).*

1. — Does the loading station fix the charges for the whole distance and collect the amount?

2. — Do these charges (in addition to the cost of carriage properly speaking) include the station charges, cost of loading, of unloading and of transhipping ?

3. — On what bases are these additional charges drawn up (each category separately) ?

4. — Who is responsible for the station charges?

c) *Transfer of goods from the loading system to the receiving system.*

1. — Are there joint stations at which the goods are transferred?

What equipment is provided for facilitating transhipment, that is to say, are there platforms with the standard gauge on one side and the light railway on the other?

Are there special platforms for unpacked (raw) goods, etc.?

What are the detailed arrangements for dealing with these ?

2. — Are there, at these stations, joint staffs (under both systems) or are there special employees of each system?

3. — How is the actual transhipment done, and at what moment does the responsibility of the loading system end?

4. — If on delivery, anything missing or damaged is noted, how is the compensation fixed?

Is it done by the joint staff of by that of the destination station?

In this case, what guarantee has the loading station that the compensation agreed by the destination station is in fact reasonable or the claim well founded ?

5. — If the two systems be separeted by a canal — involving the use of a ferry — what in detail is the system of working in force?

For this special case, please reply to each of the above four questions, 1 to 4.

d) *Use of motor vehicles etc.*

1. — Are the railways in principle authorised to set up transportation services by water or by motor vehicles as auxiliary transport (each in its own area) ?

2. — In this case, what conditions are laid down as regards these auxiliary transportation undertakings, especially as regards goods which in practice can be carried by the standard gauge, or by the light railway system ?

[621. 152.8 & 625. 616]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

12th SESSION (CAIRO, 1933).

QUESTION XIII:

The use of rail motor cars on secondary railway lines,

REPORT No. 3

(*Italy and Colonies*; *Africa except the British Dominions and Colonies*; *Mexico*; *South America*),

by Mr. LA VALLE,

Ingénieur, Inspecteur en chef, Directeur du Bureau Central du Conseil technique près de l'Inspectorat général des Chemins de fer, Tramways et Automobiles, Rome,

and Mr. MELLINI,

Ingénieur, Inspecteur supérieur de l'Inspectorat général des Chemins de fer, Tramways et Automobiles, Rome.

FIRST PART

I. — Foreword.

The question of rail motor cars has for some years been a subject for consideration for the technical and operating officers of railways and tramways; only to mention recent information, we note that this question was discussed at the Congress of the International Union of Tramways and Light Railways at Barcelona in 1926, at the subsequent Congress of the same Union at Rome in 1928, and at the Madrid Session of the International Railway Congress Association in 1930.

The technique of manufacture has not greatly advanced during recent years, except in special cases, and the rail cars used at the present time are consequently in majority of types already proved by practice.

For this reason the information on the rolling stock which will be dealt with in chapter II, is given in a brief summary.

The limited number of replies received from the Administrations covered by our enquiry and the still more limited number of definite replies, that is to say from Administrations using rail motor cars, led us to limit the present report to particulars of the Italian lines, the Algerian lines, the Egyptian State Railways, and the Buenos Ayres Western Railway.

This information in large part relates to tests which have been in hand for many years, and which, in consequence, deserve consideration.

II. — Particulars of the rolling stock.

In Italy, on the Syracusa-Ragusa-Vizzini Railway, two rail cars have been in service since 1928, after short preliminary tests in 1926 and 1927 on the *Napoli-Piedimonte-d'Alife* line, to wit: a rail motor car built by the CEMSA Com-

pany, of Saronno, and an O. M. rail motor car, built by the O. M. Company of Milan, which have the following characteristics respectively :

CEMSA rail motor car.

Bogie vehicle.
Total length . . . . . 17.00 m. (55 ft. 9 in.).
Width . . . . . 2.50 m. (8 ft. 2 1/2 in.).
Distance between bogie centres . . . . . 12.50 m. (41 feet).
Bogie wheel base . . . . . 1.55 m. (5 ft. 1 in.).
Tare weight . . . . . 23 t. (22.6 Engl. tons).
Weight fully loaded . . . . . 27 t. (26.6 Engl. tons).
A Mercedes petrol motor built by the « Deutsche Werke » 6 cylinders, 100 × 180 mm. (3 15/16 in. × 7 3/32 in.); 1 000 revolutions per minute] 160 H. P.,
Four speeds : 10-16-25-42 km. (6.2-10-15.5 and 26 miles) per hour.
Two driving compartments.
Luggage compartment.
First-class compartment with 12 seats.
Third-class compartment with 44 seats.
Driving pairs of wheels : one per bogie.

O. M. rail motor car.

Total length . . . . . 17.00 m. (55 ft. 9 in.).
Width . . . . . 2.50 m. (8 ft. 2 1/2 in.).
Distance between bogie centres . . . . . 1.80 m. (5 ft. 10 in.).
Tare weight . . . . . 30 t. (29.5 Engl. tons).
Weight fully loaded . . . . . 34 t. (33.5 Engl. tons).
Two motors of 75 H. P. [6 cylinders 120 × 170 mm. (4 3/4 in. × 6 11/16 in.)] built by the « National Automobil Gesellschaft », of Berlin; 950 revolutions per minute.
4 speeds : 10-21-36-60 km. (6.2-13-22.4 and 37.3 miles) per hour.
Two driving compartments.

The *Italian State* Railways have had in service, since 1927 on the secondary lines, three rail motor cars like the CEMSA mentioned above and another of a similar type but smaller with a distance between bogie centres of 8.55 m. (28 ft. 1/2 in.), 100 H. P. motor, 6 cylinders, 140 × 160 mm. (5 1/2 in. × 6 5/16 in), 1 000 revolutions per minute, having 48 seats and weighing empty 23 t. (22.6 Engl. tons).

A tramway company (the *Trazione-Elettrica Lombarda* Company) has had in service, since 1926, a 4-wheeled Schneider rail motor car 9.25 m. (30 ft. 4 in.) long :

Wheel base of 3.60 m. (11 ft. 10 in.).
Two driving compartments, four-cylinder motor.
Plate clutch with a Fieux make and break.
4 speeds 20-40 km. (12.4 to 24.8 miles) per hour.
Cardan shaft transmission.
Accommodation for 50 passengers, of which 33 seats.

A trailer of the same type is used.

The same Company has had in use since 1927 a Renault rail motor car of 45 H. P. with 2 radial pairs of wheels, one pair of which is driving :

Weight 11.4 t. (11.2 Engl. tons).
55 places of which 30 seats.
Two driving compartments.
Speed 35 km. (21.7 miles) per hour.

On the *Fidenza-Salsomaggiore* line, of standard gauge, connected with the State Railways there has been in service, since

1926, an articulated train composed of two bodies on three bogies, the bogie in the centre carrying the motor.

Each carriage is 10.90 m. (35 ft. 9 in.) long and has a driving compartment at the outer end; one of the bodies has room for 72 second class passengers, with seats for 36, and the other a luggage compartment and 18 first class seats.

The motor made by the Continental Motor Company, of Detroit, has the following characteristics :

6 cylinders 114 × 146 mm. (4 15/32 in. × 5 3/4 in.); working speed 2 000 revolutions; H. P. 105; 4 speeds, hydrodynamical control; Itala 4-speed gear box; one pair of wheels of the center bogie is driven.

Besides the above vehicles of the « railway » type, mention should be made of a light vehicle of the « motorbus » type built in accordance with the Narizzano patent, which has been tested from time to time since 1926, and which since 1930 has been in regular service on the lines known as the « Ferrovie Salentine ».

This vehicle has two pairs of wheels one of which is driving, with a wheel base of 3.50 m. (11 ft. 6 in.); length 9.10 m. (29 ft. 10 in); 28 seats and 10 standing places; single driving compartment; a Spa 4-cylinder motor, 100 × 140 mm. (3 15/16 in. × 5 1/2 in.); 1 700 revolutions per minute; 34 H. P.; tare weight 8.4 t. (8.26 Engl. tons) and weighing, when fully loaded, 12 t. (11.8 Engl. tons); hand and air brake.

Change speed, reverse, reduction gear; whole forming a single unit on the Narizzano system; transmission by Renold silent chain; maximum speed on the level 44 km. (27.3 miles) per hour.

The *State Railways* have also in service Diesel-electric rail motor cars of the Fiat-Brown-Boveri type.

The Diesel-electric bogie rail motor cars of the Fiat Company used by the Italian State Railways on standard gauge lines have the following principal characteristics :

Length of body	17.00 m.(55 ft. 9 in.).
Width	2.86 m. (9 ft. 4 1/2 in.).
Maximum weight per axle :	
Leading bogie	11.40 t. (11.2 Engl. tons).
Trailing bogie	8.65 t. (8.5 Engl. tons).
Weight of the rail motor car	44.00 t. (43.3 Engl. tons).
Maximum speed	55 km. (34.2 miles) per hour.
Seats, 1st-class : 8.	
Seats, 2nd-class : 30.	
Standing places : 20.	

Luggage compartment, lavatory, 180-H. P. 4-stroke, solid injection.
Diesel motor, with 6 cylinders 200 × 270 mm. (7 7/8 in. × 10 5/8 in.); 750 revolutions per minute.
Direct current dynamo,
with independent excitation directly coupled to the Diesel motor, to work as starting motor,
the exciter for the dynamo, for charging the batteries, and for feeding the auxiliaries, driven by belt.
2 traction motors in parallel.
Battery of accumulators for starting electrically the Diesel motor and the auxiliaries.

The Italian State Railways have also a Fiat rail motor car of a smaller type used on the narrow gauge lines [0.95 m. (3 ft. 3 3/8 in.) gauge] in Sicily.

The State Railways have also in continuous service, since February 1932, a light rail motor car of the « motorbus » type, built by the Fiat Company and which has the following general characteristics :

Length of body, 7 m. (22 ft. 11 5/8 in.).
Width, 2.35 m. (7 ft. 8 1/2 in.).
2 pairs of wheels, the trailing of which is the driving pair.

Wheel base, 3.00 m. (9 ft. 10 1/8 in.).
Fiat motor, 6 cylinders, 92 × 132 mm. (3 1/4 in. × 5 13/64 in.); 2 000 revolutions; 65 H. P.; 4 speeds and reverse.
Maximum speed on the level 60 km. (37.3 miles) per hour.
25 seats; 9 standing places.
Tare weight 6.6 t. (6.5 Engl. tons); service weight 9.4 t. (9.25 Engl. tons).
Single driving compartment.
Hand brake and foot brake acting on the wheels.
Electric starter (accumulators and small motor).

The rail motor car carries gear by means of which it can be turned for running in the reverse direction.

The consumption in service per 100 km. is 35 kgr. of petrol and 1.5 kgr. of lubricating oil (124 lb. and 4.3 lb. per 100 miles respectively).

The rail motor car is able to haul a trailer which has 32 seats, carried on 2 pairs of wheels, with a wheel base of 3 m. (9 ft. 10 1/8 in.) and a tare weight of 4.6 t. (4.5 Engl. tons).

The *Piacentina Tramway* Company has had in service, since May 1930, a CEMSA rail motor car of the small pattern already mentioned in connection with the State Railways, on the Piacenza-Cremona line.

Finally, on the *Poggibonsi-Collè Val d'Elsa* Railway, since July 1931, a small « Ganz » 4-wheeled rail motor car has been used, one pair of wheels being driving, the wheel base being 2.80 m. (9 ft. 2 in.), the tare weight 4.3 tons and the numbers of seats 16. Other characteristics :

N. A. G., Berlin, motor 4 cylinders 87 × 136 mm. (3 7/16 in. × 5 11/32 in.) (1 600-2 600 revolutions); 24 H. P., 4 speeds (11-50 km. (6.8-31 miles) per hour; cardan shaft transmission; 2 brakes acting on the axles.

* * *

Serro-Santuario della Madonna della Guardia line (near Genoa). — To complete our enquiry into the Italian experiments, we will mention a special line all on a gradient in one direction, which deserves to be reported owing to the special construction of its track which is carried on tarred concrete longitudinal sleepers, and to the fact that it uses only rolling stock with explosion motors for traction purposes.

The line is laid on a steep gradient of 80 °/₀₀ (1 in 12.5) and the rolling stock has wheels with solid rubber tyres 200 mm. (7 7/8 inches) wide; the wheels carry discs which act as flanges against flat projections on the four foot side of the concrete sleepers.

The depth of the flange is 30 mm. (1 3/16 inches) when the rubber is new and increases to 70 mm. (2 3/4 inches) when the rubber is worn.

Although the line has sharp curves [25 m. (1 1/4 chains radius)] experience has shown nonetheless that the cross inclination of 1 in 20 given to the 2 concrete rails is in itself sufficient to keep the stock central with the track.

The length of the track is about 9 km. (5.6 miles), and the gauge 1 metre (3 ft. 3 3/8 in.).

The passenger service has been worked since 1928 by means of 6 rail motor cars built by the « Autoguidovie Italiane » Company of Piacenza — which also operates the line — the vehicles having the following principal characteristics :

Length of body . . . 7.40 m. (24 ft. 3 in.).
Width . . . . . 2.00 m. (6 ft. 6 3/4 in.).
2 pairs of wheels with a wheel base of . . 2.70 m. (8 ft. 10 in.).
Tare weight 6 tons; service weight 8 tons; 18 seats; 10 standing places; driving from both ends.
Detroit Continental motor, 6 cylinders 104 × 125 mm. (4 5/64 in. × 4 29/32 in.) (2 100 revolutions), 80 H. P.; electric starting gear; 4-speed gear box and speed reduction [4 to 17 km. (2.5 to 10.6 miles) per hour].

Two hand brakes, one of which acts on the transmission gear and the other on the wheels.

These rail motor cars and the type of rails have been selected in order to obtain a high degree of adhesion so as to be able to run up the severe gradient without special devices.

The coefficient of adhesion has been shown, by the experiments carried out, to be 1 to 2.3.

In May 1930 as turntables had been fitted at the ends of the line, two other rail motor cars similar to the preceding ones but shorter and with one less driving compartment have been used; the fixed wheel base was reduced to 2.50 m. (8 ft. 2 7/16 in.).

On the *Algerian* lines of the *French State* there are in service Renault rail motor cars (type P F) with 6-cylinder engines 100 × 160 mm. (3 15/16 in. × 6 5/16 in.); 75-100 H. P. (2 200 revolutions); tare weight 23 t. (22.6 Engl. tons); 4 speeds; electric starter; length of body 16.20 m. (53 ft. 2 in.); distance between bogie centres 11 m. (36 ft. 1 in.); bogie wheel base 1.80 m. (5 ft. 11 in.); body having postal compartment, and 1st, 2nd, and 3rd class compartments; total seats 84; one driver's compartment; weight fully loaded 27 t. (26.6 Engl. tons); maximum speed 65 km. (40.4 miles) per hour.

The same Railway also uses Renault-Scemia rail motor cars with 4 cylinder petrol motors type R S 125 × 160 mm. (4 29/32 in. × 6 5/16 in.), running at 1 500 revolutions per minute, 35-40 H. P., 4 speeds; length 9.40 m. (30 ft. 10 in.), carried on 2 pairs of wheels, wheel base of 3.60 m. (11 ft. 10 in.); there are 2nd and 3rd class compartments, for 69 passengers of which 39 seated; empty weight 11.4 t. (11.2 Engl. tons); maximum speed 40 km. (24.8 miles) per hour.

The *Algerian State* Railways have also de Dion petrol rail motor cars in service, these being of the 2 H 2 type [4 cylinders, 95 × 140 mm. (3 3/4 in. × 5 1/2 in.)], engine running at 2 000 revolutions, giving 15 to 22 H. P.

Length of the vehicle. 6.15 m. (20 ft. 2 in.).
Wheel base . . . . . 4.25 m. (13 ft. 11 in.).
Luggage compartment, 2nd and 3rd class compartments, 44 places of which 21 seated.
Tare weight . . . . . 5 tons.
Body of the motor bus type.
Maximum speed: 40 km. (24.8 miles) per hour.
One driving compartment.

Finally on the same System there are still in service Rowan steam cars which have a vertical water tube boiler:
2 cylinders 165 × 130 mm. (6 33/64 in. × 5 1/8 in.).

100 H. P.; working at 15 kgr. (213 lb. per in²) pressure.
Fuel: coke.
Length of the body: 10.80 m. (35 ft. 5 in.).
The rail motor car is carried on 3 pairs of wheels with a motor bogie at the leading end and a carrying pair of wheels at the other.
The wheel base is 5.53 m. (18 ft. 2 in.).
The motor is placed at the leading end; there are 2nd and 3rd class compartments; room for 42 passengers of which 36 seated.
Tare weight: 13.3 t. (13.1 Engl. tons).
Rod drive.
Railway type of body.
Maximum speed: 30 km. (18.6 miles) per hour.
One driver's compartment.

These rail motor cars have been in use for nearly 30 years as mentioned in the report drawn up by Mr. Beghin for the Madrid Congress.

* * *

Paris-Lyons-Mediterranean Company (Algerian System). — This Company uses Berliet petrol rail motor cars of greater power and weight than those

mentioned in the report presented at the Madrid Congress

The motor has 6 cylinders 125 × 140 mm. (4 29/32 in. × 5 1/2 in.); 75 H. P.; there are 2 pairs of wheels the leading of which is driven; room for 52 passengers, 42 seated; there is a luggage compartment and a postal compartment; the tare weight is 15 t. (14.8 Engl. tons); the fully loaded weight 19 t. (18.7 Engl. tons); the car is of the railway type; there is a driver's compartment at one end; the maximum speed is 50 km. (49.6 miles) per hour (with or without trailer which weighs 8 tons); a single driver is used.

The rail motor car has been in service at intervals during the last three years, and in continuous service for the last two years.

* * *

The other railways who have supplied useful information are the Egyptian State Railways and the Buenos Ayres Western Railway.

The *Egyptian State* Railways have had in service for the last two years steam rail motor cars with 150 H. P. engines, the cars consisting of articulated units, two bodies being carried on 3 bogies, the vehicles being built at Birmingham.

Total length . . . 31.00 m. (101 ft. 8 1/2 in.).
Bogie wheel base. 2.30 m. (7 ft. 6 35/64 in.).
Distance between bogie centres . . 13.45 m. (44 ft. 2 in.).
1st, 2nd and 3rd class compartments and tender in one of the bodies (2 tons of water in the tank and one ton of coal).
Luggage compartment, 3rd class compartment and boiler in the other body.
109 seats.
Total weight : 52.12 tons.

The driving bogie is the middle one, and is under the tender and the boiler.

The rail car has two driver's compartments so that it can be driven easily from either end; it is fitted with hand brake and vacuum brake. It runs without a trailer and has a maximum speed of 60 km. (37.3 miles) per hour.

The vehicle is driven by a driver assisted by a fireman.

The Buenos Ayres Western Railway uses steam rail motor cars of the « Sentinel » type with 2 vertical cylinders of 100 H. P., with railway type of body, with 1st and 2nd class compartments luggage compartment and lavatory; a total of 41 seats; total weight 26.4 tons; there are driving compartments at both ends; the maximum speed is 65 km. (40 miles) per hour without trailer and 52 km. (32 miles) with a trailer.

The driving staff consists of a driver and a fireman.

* * *

The rail motor cars with internal combustion motors which we have spoken about in this chapter have generally : a gear box; cardan shaft transmission; electric starting and lighting; foot operated brake.

Several of them also have compressed air or vacuum brakes, at least when hauling trailers; nearly all have 4 forward speeds and reverse and are fitted with roller bearing axle boxes.

In Table I, the principal details of the rail motor cars in service are given.

Before finishing this chapter we should also mention the Portuguese Mozambique Railways the Administration of which has reported that they have completed (February 1932) the purchase of 2 Diesel-electric rail motor cars for lines of a maximum gradient of 1 in 67, a minimum radius of 120 m. (6 chains), and that the type with the following characteristics has been selected :

8 cylinders; 200 H. P. at a pressure of 720 mm. (28 3/8 inches) of mercury and at 20° C. (68° F.); 900 revolutions per minute; weight of motor 2 500 kgr. (5 500 lb.); D. C.

TABLE I. — **Principal characteristics of the rail motor cars.**

RAILWAYS.	Type of rail motor car.	Bogies or axles.	H. P.	Tare weight, metric tons.	Number of places.	Tare weight per passenger.	Weight, loaded.	Maximum speed on the level.	Driving compartments.
Italian State	Cemsa, petrol.	2 bogies.	150	28	70	400	32	55	2
	Cemsa, petrol.	2 bogies.	100	23	45	510	24	55	2
	Fiat Diesel-electr.	2 bogies.	180	44	50	880	47	55	2
	Fiat Diesel-electr.	2 bogies.	150	44	50	880	47	55	2
	Fiat, petrol.	2 axles.	65	6.6	34	200	9.4	60	1
Algerian State	Renault.	2 bogies.	70-100	23	54	420	27	65	1
	Renault, R S 4.	2 axles.	40	11.4	69	160	15	40	1
	De Dion, 3 H 2.	2 axles.	22	5	44	110	8	40	1
	Rowan, steam.	1 bogie. 1 axle.	100	13.3	42	310	16	30	1
P. L. M. (Algerian lines) .	Berliet.	2 axles.	75	15	52	290	18.5	50	1
Egyptian State	Steam.	3 bogies.	150	45	109	410	52	60	2
Buenos Ayres Western .	Sentinel, steam.	2 bogies.	100	26.4	41	640	30	65	2
Syracusa-Vizzini	Cemsa, petrol.	2 bogies.	160	23	56	410	27	42	2
	O. M., petrol.	2 bogies.	2×75	30	56	530	34	60	2
Poggibonsi-Colle d'Elsa .	Ganz, petrol.	2 axles.	24	4.3	16	270	5.7	50	1
Ferrovie Salentine . . .	Narizzano, petrol, type II.	2 axles.	34	8.4	24	350	12	44	1
Fidenza-Salsomaggiore. .	Laviosa, petrol.	3 bogies.	105	24	80	300	30	40	2
Piacenza-Cremona . . .	Cemsa, petrol.	2 bogies.	100	23	48	470	26	42	2
Serro-Madonna della Guardia.	Laviosa, petrol.	2 axles.	80	6	28	210	8	17	2 and 1

generator, type 280/32, giving 134 kw. at 900 revolutions, voltage 200 to 600 series, coil excited by battery, weight 1 760 kgr. (3 875 lb.); flexible coupling; water and oil coolers; two D. C. motors in series; power 61 kw. at 320 volts and 1 120 revolutions per minute; 55 seats, 6, 1st-class, 17, 2nd-class, and 32, 3rd-class, room for 20 passengers standing. Upholstered chairs are provided in the case of the 1st and 2nd classes, and wood seats in the 3rd. There is a small luggage compartment, but no compartment for the post. The weight is 48.5 tons.

The fuel consumption expected is 200 gr. (0.44 lb.) of oil per H. P.-hour.

III. — Particulars of the lines.

In Italy, rail motor cars are in service on standard and narrow gauge lines (0.95 m. (3 ft. 3 1/8 in.) with gradients of 1 in 40, and curves as small as 100 m. (5 chains) radius for the standard gauge and 80 m. (4 chains) for the narrow gauge.

The Egyptian State Railways have in service steam rail motor cars on standard gauge secondary lines on the level with large radius curves ; and the case is the same with the Buenos Ayres Western Railway.

In Algeria [gauge 1.055 m. (3 ft. 5 9/16 in.)] the State railway system uses Renault rail motor cars on lines with a maximum gradient of 1 in 100 and a minimum radius of curve of 200 m. (10 chains), and Rowan steam rail motor cars and small Renault and de Dion vehicles on the lines with sharp curves, 25-50 m. (1 1/4 to 2 1/2 chains) with gradients up to 1 in 33.

In Table II the main characteristics of the lines operated are summarised.

IV. — Operating results.

The rail motor cars dealt with in the present report have been in use for varying periods ; several among them have been in use since 1927 and even before that date.

From tests carried out or being made in Italy and the replies from Administrations in other countries, it appears that generally the rail motor cars give satisfaction ; that the costs of repair are not excessive and in several cases even lower than those expected : that the replacement of parts is easy and simple and that the time out of service for repairs and overhauls is also kept within narrow limits.

The average consumption of fuel, petrol and oil, for motors is generally between the limits of 16 to 20 gr. per tkm. (14.77 to 18.46 drams per Engl. ton-mile).

Although certain questions were put to the Administrations and these have supplied some indication as to the repair costs, wages, and total expenses, this information cannot be given here as by itself it is of little value ; moreover in view of the different values of currencies and varying exchange rates, especially at the present time, no convincing deductions could be drawn from them.

The speed on the level lies between 40 and 60 km. (24.8 and 37.3 miles) per hour.

The vehicles are driven nearly always by a single man (2 in the case of the Diesel-electrics).

The working is in all cases cheaper than with steam because of the saving in the wages of the staff ; it is the same for the minimum consumption of fuel due to a smaller consumption when running and to no fuel being used during stops.

The weight per passenger place is 400 to 500 kgr. (880 to 1 100 lb.) in the petrol rail motor cars with « railway » bodies and 200 to 300 kg. (440 to 660 lb.) for rail motor cars with the light « motorbus» type of body.

The weight is notably greater in the case of the steam rail cars, and greater still in the case of the Diesel-electrics.

In Table III the principal operating results are summarised.

V. — Summary.

Substantially all the tests considered above apply to rail motor cars with mechanical transmission, mostly with explosion motors; some have steam motors, often of types in use before 1928 and which since that date have made scarcely any progress. This is due to the fact that in Italy, and also elsewhere, the high price of the first rail motor cars of each type has not encouraged the operators who, more than anybody, in view of the limited traffic and economy of operation, would have been disposed to put them into service ; to state it briefly the purchase price was prohibitive for many administrations, and those who made trials with them did so on a very limited scale ; in many cases they only used a single machine of one type, retaining also in service the whole of the stock used when operating by steam.

The whole of the above conditions were obviously most unfavourable to experimenting with rail motor cars on a large scale.

The fact that their use has not become general has not favoured any appreciable

RAILWAYS.	Lines.	Length, (miles).	Gauge.	Minimum radius of curves, (chains).	Maximum gradient.	Type of rail motor car.	Number of trains.
Italian State	Leghorn-Colle-Salvetti. .	11	Standard.	25	1 in 200	Cemsa.	8 trains daily (both directions).
	Ronciglione-Capranica . .	4.3	Standard.	12	1 in 500	Fiat.	10 trains daily (both directions).
	Palermo-Messilmeri . . .	10	0.95 m.	4	1 in 30	Fiat.	8 trains daily (both directions).
	Piacenza Armerina-Caltagirone	22	0.95 m.	5	1 in 28	Fiat.	2 trains daily (both directions).
	Cerignola-station. . . .	4.3	Standard.	?	1 in 55	Fiat.	24 trains daily (both directions).
Algerian (State)	Bouira-Aumale	26	1.055 m.	10	1 in 53	Renault.	1 train daily (both directions).
	C. F. R. A.	20	1.055 m.	1 1/4	1 in 33	RS4 Renault.	4 trains, 5 days per week.
	C. F. R. A.	20	1.055 m.	1 1/4	1 in 33	3H2 de Dion.	4 trains, 5 days per week.
	C. F. R. A.	10	1.055 m.	2 1/2	1 in 50	Rowan.	4 trains, 6 days per week.
P. L. M. (Algerian lines) .	Orléansville-Ténès . . .	35	1.055 m.	6 1/4	1 in 50	Berliet.	2 passenger trains daily (both directions). 1 goods train every second day.
Egyptian State	Secondary lines	...	Standard.	...	Level.	Steam.	Varying according to needs (excursions).
Buenos Ayres Western. .	Secondary lines	...	Standard.	25	...	Sentinel.	3 days per week.
Syracusa-Vizzini . . .	Secondary lines	77 77	0.95 m. 0.95 m.	5 5	1 in 36 1 in 36	Cemsa. O. M.	4 trains daily (both directions) on part of the line.
Poggibonsi-Colle Val d'Elsa.	Secondary lines	4.6	Standard.	5	1 in 43	Ganz.	6 trains daily (both directions).
Ferrovie Salentine . . .	Gagliano-Tricase. . . .	6.8	Standard.	15	1 in 67	Narizzano.	2 trains daily (both directions).
Fidenza-Salsomaggiore. .	Secondary lines	6	Standard.	5	1 in 45	Laviosa.	8 trains daily (both directions).
Piacenza-Cremona . . .	Secondary lines	21	Standard.	1 3/4	1 in 71	Laviosa.	2 trains daily (both directions).
Serro-Madonna della Guardia.	Secondary lines	5.6	1.00 m.	1 1/4	1 in 125	Laviosa.	4 trains daily (both directions).

TABLE III. — **Operating results.**

RAILWAYS.	Rail motor cars.	No. of rail motor cars.	In use since	Annual distance run (km.).	Consumption per 100 km.		Periodical interruptions of the service for repairs and for maintenance.
					Petrol.	Oil. Kgr.	
Italian State	Cemsa 150 H. P.	3	1927	20 000 to 40 000	83 litres.	3.2	70 days per annum.
	Cemsa 100 —	1	1927	»	83 litres.	...	70 days per annum.
	Fiat 180 —	2	1931	»	70 kgr. heavy oil.	...	70 days per annum.
	Fiat 150 —	2	1931	»	70 kgr. heavy oil.	..	70 days per annum.
	Fiat petrol 65 —	2	1931	»	48 litres.	...	...
Algerian State	Renault 100 H. P.	..	...	25 000	70 litres	4.5	30 days per annum.
	Renault 40 —	...	...	30 000	60 litres	6	100 days per annum.
	De Dion 22 —	...	...		40 litres.	2	50 days per annum.
	Rowan 100 —	...	...	6 000	600 kgr. coke.	2.3	30 days per annum.
P. L. M. (Algerian lines) .	Berliet 75 H. P.	...	1929	42 000	46.7 litres.	1.8	70 days per annum.
Egyptian State	Steam 150 H. P.	...	1931	...	350 kgr. coal.	4.2	...
Buenos Ayres Western .	Steam Sentinel 100 H. P.	...	...	2 500	335 kgr. coal.	...	...
Siracusa-Vizzini. . . .	Cemsa 160 H. P.	1	1928	6 000	93 litres.	1.4	70 days per annum.
	O. M. 150 —	1	1928	26 000	83 litres.	2.4	
Poggibonsi-Colle Val d'Elsa.	Ganz 24 H. P.	1	1931	26 000	22.5 litres.	...	A few days a year.
Ferrovie Salentine . . .	Narizzano 34 H. P.	1	1926 1930	15 000	27 litres.	...	30 days per annum.
Fidenza-Salsomaggiore. .	Laviosa 105 H. P.	1	1926	24 000	70 litres.	3.5	70 days per annum.
Piacenza-Cremona . . .	Cemsa 100 H. P.	1	1930	24 000	80 litres, with trailer.	...	90 days per annum.
Serro-Madonna della Guardia.	Laviosa 80 H. P.	8	1928 1930	6 000	80 litres.	..	30 days per annum.

technical improvement, nor a reduction in the prices of the stock.

Furthermore, the Railway Administrations are always giving more attention to the integration of their proper functions — large quantities and long distances — by road motor services and in this way the motorbus has hindered the already difficult development of the rail motor cars.

We are of the opinion, however, that so long as a railway line already in existence can be operated usefully it should be preserved; it is always an inheritance and a source of wealth which if needs be can demonstrate its utility even when doubt has been cast on the latter.

And if, moreover, certain railway services can be replaced by road motor services, there is nothing technically and financially to hinder the working of a service of motor coaches on the rails, by the use of rail motor cars of the « railway » type or, if needs be, of the « motorbus » type, provided that it is not a question of traffic over lines situated at too great a distance from the inhabited centres.

The rail motor cars on rails are criticised because their first cost is too high — an element which always varies and which can be reduced if the use of these cars is made more general.

These drawbacks are as a rule to be excluded in the case of machines with electrical transmission ; as regards the other machines with mechanical transmission the experience in cases of which we have direct knowledge has not been unfavourable in the case of the services with rail motor cars adapted to the railways and for lines with easy gradients on which any necessary extra capacity is obtained by being able to use trailers.

Further technical progress may easily enable the conditions to be improved, but it depends on the development of the service in question.

The visible and effective limitation of the use of rail motor cars with internal combustion motors is due above all to the inability of the motor, in practice, to give very wide variations of power ; consequently unless excessive power be used, they can only be utilised in a proper manner on lines with gradients of less than 1 in 33 ; but this problem is in reality a financial one, because we see that the motorbuses running on the road fitted with motors of the same kind are used widely even on steep and long gradients.

The real defect of the rail motor coach, as compared with the road motorbus, is its excessive tare weight.

In this report, no mention has been made of the omnibus type of rail motor car on pneumatic tyres, because these have not yet been tried in the countries considered in this report.

As regards the steam motor cars they naturally have not the above mentionned drawback ; but here it is a question of machines which, even if they have been highly developped technically, as those used on the Egyptian System, and on the Buenos Ayres Western Railway, cannot be used on a large scale in view of their price, financial reasons in all countries requiring the greatest economy and the substitution for coal of definitely cheaper fuel with a saving of staff and of the work done by the staff.

Moreover the two cases of steam rail motor cars — however favourable — in the countries considered in this report, are not sufficient by themselves for any general conclusions to be deduced and since it is a question almost exclusively of machines made in England, better and better-founded factors — because they relate to greater a number of applications — will be brought out in other reports on this subject.

The economic crisis through which the world is passing today is the cause of another drawback : a machine that can be used with advantage from the general point of view, i. e. financial, in

the country where it is built, is not at the present time, owing to the high protective duties, equally suitable in other countries where there own manufacturers are producing other types of machines.

The result is that in each producing country it is necessary, in practice, to limit oneself to carrying out experiments with rolling stock wholly or partially of national manufacture.

However, at least in the countries in question, the trial of rail motor cars has brought out one factor favorable to their adoption, because it continues to give satisfaction to the administrations, even though of relatively recent use.

The trials already carried out to provide a service of light and frequent trains — such as are required on several railway systems — on lines of limited traffic, with the object of attracting a greater number of passengers, or to avoid their loss, due to too long intervals between trains, have shown that the rail motor cars can give an efficient service, satisfactory to the public and cheaper, but — and we would stress this point — it would be well to extend their use so as to make it more useful and more economical to the railway companies and through mass production to get down to a much lower cost of construction, equal to that of motor omnibuses.

The conclusions taken at the Madrid Congress are we think still valid in substance if the slight modifications resulting from our enquiry are made; i. e. :

1. Above 150 H. P., the Diesel-electric rail motor car has to be used owing to the difficulty of the mechanical change of speed, unless technical progress produces mechanical change speed gears, differing from the present type, which are more or less the same as those in use on motor omnibuses.

2. In order to get a real benefit from the rail motor cars, a wider use must be made of them, on a service adapted to them, and in actual substitution of steam services, which will lead to a better and cheaper utilisation of the rail motor car. The builders will be encouraged to produce types in series with reasonable selling prices; otherwise the production and the use of rail motor cars will not overcome the dead point of the present position.

SECOND PART

After having considered, from a strictly technical point of view (First Part), the question of the rail motor cars to be used on secondary railways, it is useful to tackle one of the most urgent and important of the problems applying to these lines with little traffic : that of the effect of the practical results of the application of these new methods of traction on the vitality of these railway communications, that the present world financial crisis, and the ever growing competition of motor vehicles, have put in extremely unfavourable if not hopeless conditions.

Before examining the details of the question, it would be as well to report here some of the replies given by the Administrations to which the questionnaire was submitted.

a) Italian State Railways.

(2nd question). — The rail motor cars ought to give a service as satisfactory as that given by road motor vehicles, from the point of view of the average speed, frequency of services and fares; their characteristics should be naturally in relation with the characteristics of the lines to be worked.

(3rd question). — The local conditions and the real importance of the competition made by the road motor vehicles should be looked into : it would not be possible, for example, to retain to the railway the passenger traffic in the cases in which the railway lines are some distance away from the towns and localities served by the road vehicles.

b) **Paris-Lyons-Mediterranean Railway. (Algerian lines).**

(1st question). — The rail motor coach can be an economical machine on a secondary line, where it is not in competition with a passenger service with road motor vehicles. It appears however that it is of no value except on lines where the operating methods can be simplified.

Transport of goods, even on lines with very reduced traffic, will make it necessary to use steam traction, so long as there has not been built a more powerful type of rail motor coach, which can trail 2 or 3 goods vehicles, at the same time that it covers the passenger traffic by the seats it provides.

It appears moreover that for the future, the solution of the powerful rail motor car is to be found in the use of the Diesel engine. It is in this direction that we shall direct our enquiries if we are to develop the use of rail motor cars.

(2nd question). — The running speed should be at least equal to the commercial speed of a road motor vehicle, that is 50 km. (31 miles) per hour. The rail motor coach should have a margin of speed of 10 km. (6.2 miles) at least above this figure. The acceleration should be such as will enable it to get away quickly; 4 speeds would appear to be useful; the weight should be reduced in order not to overload the motor on gradients. The weight per axle should be a maximum of 14 tons on the standard gauge, and 12 tons on the narrow gauge. The rail motor car should not require more than 2 men to operate it. Its motor ought to be of ample size.

(3rd question). — Yes, if the time tables have been well selected and if the rail motor cars are able to carry luggage and parcels traffic. The stations must, however, be near the towns. — No, in the opposite case, the road motor coaches have the advantage that they serve the towns directly.

c) **Algerian State Railways.**

We consider in fact the rail motor car to be one of the basic factors in operating secondary lines in an up to date way. But we have not yet come to the trial stage as regards the methods of traction, except as regards the petrol motor (rail motor cars with Diesel motor; electric traction, mechanical drive; locotractors, pneumatic-tyred-cars, etc.) and we cannot in consequence give any precise information on the general problem of the replacement of steam locomotives by rail motor cars for the transport of passengers on secondary lines.

d) **French West African Railways.**

In our opinion, the rail motor car can remedy in certain cases the harm done by road motor competition. The question however is complex and its solution should be appropriate to the operating conditions of each system. We have just taken up its study on the Thiès to the Niger Railway. We have in mind the use of rail motor cars running at a speed slightly higher than that of the trains now running on the same sections, and which with a trailer can provide accommodation for about 100 passengers, with a small luggage compartment.

e) **Tunisian Railways.**

The secondary lines of this system run through districts which are rather poor and where there are few towns and these generally rather far away from the stations serving them. From this fact the road is more convenient than the railway and road motor competition has become very serious. It appears quite clearly today that we shall not be able to retain to our secondary lines their passenger traffic, whatever rolling stock is used in working these lines. Under these conditions we have prepared and to some extent have already put into operation a programme involving the sup-

pression of the passenger trains on most of the secondary lines and their replacement by services of motor coaches giving the same facilities.

f) Cordoba Central Railway (Argentine).

The rail motor cars can be of use for suburban and secondary railways with moderate traffic, when about 50 miles long. These rail motor cars should be of the articulated type, and should be light, with an axle weight not exceeding 15 tons. They should have 60, 1st and 2nd class, seats, and be fitted with petrol, petrol-electric or Diesel motors. The latter (of about 250 H. P.) is the one preferred.

g) Egyptian State Railways.

The rail motor coaches should have the following characteristics : able to run in both directions, without having to turn the vehicle; moderate fuel consumption; fuel and water supplies corresponding to the requirements; light weight; high rate of acceleration; moderate maintenance and repair costs.

h) Lourenço Marquès Harbour and Railway (Mozambique).

(1st question). — Yes, if the rail motor cars are used on lines without too many gradients.

(2nd question). — The average speed should not be less than 40 km. (25 miles), seeing that light lorries can reach this speed on the competing routes. The rail motor cars can be used already on light railways laid with rails weighing 30 kgr. (60 lb. per yard), and require, to drive them, one European employee less than the steam trains.

(3rd question). — Yes. It is just for this reason that we are adopting rail motor cars on our system.

(4th question). — We prefer Diesel-electric rail motor cars, in order to get cheaper operating costs.

* * *

The remarks and information given above by different Railway Companies and State Railways, essentially favour the adoption of petrol rail motor cars (and similar systems) on suburban lines and on secondary lines generally, they also very clearly confirm that the most efficacious remedy for restoring to a healthy condition railways with little traffic, hit as they have been by the present crises and by the competition of road motor vehicles, should be looked for in the formula : *Light, fast, and cheap trains.*

The speed of the services has to be considered today as one of the most important factors for recovering the passenger traffic on secondary lines, which in recent years, have lost a considerable part of their customers owing to the presence of other methods of transport which were much faster than the old tramway trains hauled by an ordinary steam locomotive. To this consideration must be added the need of turning to the use of light, or very light trains, proportioning their composition to the real needs of the traffic, as far as to form if necessary trains of one single vehicle (the rail motor car) with a considerable economy of staff. This system of light trains can in certain cases be joined up with the numerical reduction of the trains worked each day, when the traffic is almost nil; on the other hand and in most cases it will make it possible to increase the existing number of trains, with a view to recovering the traffic taken away by other competing methods of transport, and to acquire new traffic by the facility and the speed of the journeys.

The light train can therefore be reduced to the most simple and economical composition, and transform itself into a petrol or heavy oil motor bus running on the rails.

From this point of view it is quite natural that the choice of the most favourable system for providing light trains should clearly lean to the different types of rail motor cars with internal combustion engines, seeing that steam traction is hardly suitable for small powers and that the electrification of railways and tramways requires important and expensive installations, which can only be adopted when the traffic exceeds a high minimum density.

The use of light type trains hauled by a rail motor car with a single driver and another employee (guard) would appear to best meet the needs of suburban traffic when the following considerations are taken into account :

a) Maximum flexibility, through the increase in the number of trains in the hours when the traffic in densest. The uniform make-up of the trains makes it possible to reduce to the minimum the space between two following trains, not only by the uniformity of acceleration at starting and of the running speeds, but also by the time required for passengers to get in and out of the cars. The old system of increasing the composition of the trains during the rush hours requires the use of locomotors in place of rail motor cars and has been shown generally to be less elastic.

b) Maximum frequency of trains.

c) Maximum frequency of stops.

These are very remarkable advantages, especially for the suburban services of large cities and industrial towns.

Furthermore it is obvious that a light train makes it possible to obtain :

a) The greatest acceleration when starting, and the greatest retardation when stopping at the different stations, with very high train speeds when running over short distances.

b) The greatest reduction in the operating expenses, owing to the reduced weight per place provided; the possibility of making arrangements so as to have the highest possible coefficient of occupation of the available places; wages reduced to the minimum, by using two men only in each train.

The rail motor car with petrol motor or heavy oil engine has characteristics which are very favourable for working in the most economical and up to date way railways with little traffic, in the case in which electrification cannot be considered as a solution financially recommendable; this explains clearly the very real interest that secondary railway circles take in the rail motor car even though from the technical point of view the problem cannot be considered so far as completely solved, and the price of the said rail motor cars is still extremely high.

The same remarks can be made as regards electric-accumulator rail motor cars.

As regards the rail motor cars on pneumatic tyres, under test, the trials so far appear to have given very favourable results, in particular on lines of local and secondary railways, with little traffic. These vehicles run without much noise, they take the points at crossings well; they get into speed very quickly and have a brake system which acts equally rapidly and which does not interfere with the comfort of the passengers; they are able to run on level and straight lines at 70 to 80 km. (43.5 to 50 miles) in ordinary service. Their cost price is not very high and the consumption of petrol is below that of a motor omnibus of equal power. They should have a great future, particularly on poor lines and for auxiliary services.

But the problem of the use of these new systems of traction in order to improve the present very serious position of the light railways cannot be considered other than as part of the much more vast and organic question of restoring secondary railways to a condition to meet the ever-growing demands of the

passengers, so as to be able to overcome the very serious present period of crisis, to be in condition to meet the formidable road motor competition, and above all to arrive at the point of winning back the favour of the public.

It is necessary to modernise, simplify and transform, for reasons both financial and progressive, the operating systems, with the help of arrangements sometimes daring and novel, especially when it is a question of railways with little traffic, whose budget has become during the last years more and more in deficit and whose past-vitality has now been turned into agony.

When the different improvements adopted to set up an economical and modern working do not produce positive results, it is well to abandon the artificial forms of vitality, such as extraordinary and temporary subsidies from the public authorities or the towns, and to recognise that the railway in question has come to the end of its work and its life. In most of these cases public road motor services well organised can give much more favourable returns for the concessionaire and the public.

It must be remembered in this respect that nearly all the railways were built before the road motor vehicles had entered into tourist, industrial and commercial use in the different countries; and that the old regulations and methods of operation — many of which are still in force — were got out when the railways represented the only rapid method of public transport. It must also be recognised that in the past the Governments themselves have built or granted concessions to build railways in very poor districts, solely with the object of leading to the revival and development of such districts, especially as at that period the railways had in fact a monopoly of transport, a state of affairs which at the present time no longer exists. Today the position, as regards the vitality of these secondary railways and the possibility and advantage of their preservation, is a very delicate one; this situation, aggravated by the results of the present world crisis, forms one of the most difficult problems to be solved in each case in which a railway can no longer exist on its own resources or is no longer in a position to meet the just demands of the population served.

In Italy, for example, a very elaborate programme is being developed for the partial or total replacement of the old secondary railways and tramways by full, up to date road motor services for passengers and goods, fully meeting the requirements of the districts. As an example we may mention the Milan-Melegnano-Lodi tramway of a length of 33 km. (20.5 miles) the receipts of which were about 100 000 lire per km., (160 000 lire per mile) and which at the end of the period of concession will be abandoned and replaced by an intense, fast and convenient service of motor vehicles giving full satisfaction to the public.

* * *

The modern operation of secondary railways and tramways would appear therefore to get further and further away from steam traction and to show its preference for electric traction, for petrol or similar rail motor cars.

The use of these rail motor cars is however very backward in most of the countries and railways with which we are dealing, whereas we have already — almost everywhere — railways and tramways operated electrically on modern, economical and rational lines, well worthy of mention.

We believe it useful therefore before coming to any conclusions to give here some information on a secondary railway electrically operated, built recently in Italy, with modern and at the same time bold ideas, and which will be open to working in a few months time; although the problem is a little outside the

question which we are considering, it may interest a Congress of railwaymen by better bringing out the limits and requirements which have to be met today in the construction and working of a modern secondary railway.

* * *

The railway in question runs from Piacenza to Bettola, and its construction was authorised in 1928 to replace an old steam tramway no longer meeting the needs of the region.

The company holding the concession considered that if the working of a newly built railway was to be healthy and prosperous financially, the most modern technical knowledge must be used, even were the costs of installation considerably increased thereby.

The old Piacenza tramway system had seen its passenger traffic reduced to 1/3rd of what it was after the war, owing to the competition of omnibuses and private cars. It should of course not be forgotten that the average speed of the trains was 12 to 15 km. (7.5 to 9.3 miles); that the carriages were built nearly 50 years ago, and were most uncomfortable, and that there were very few trains : usually 4 daily in each direction. These conditions caused the public to give up more and more this method of transport.

In the same way the goods traffic had been hindered by the lack of any proper connection with the State Railways, owing to the unfavourable characteristics of the track, the insufficient section of the rails, etc.

The new system of 92 km. (57 miles) of railway — of which the Piacenza-Bettola line of 32 km. (20 miles) is the first section — will be connected with the Piacenza station of the State, and with almost all the industrial plants of the district, so as to make is easier to recover most of the local commercial and transit traffic.

The minimum radius of the curves has been raised to 300 m. (15 chains); the gradients are nowhere greater than 1 in 50. The track is laid with flat bottom rails weighing 36 kgr. (72 lb. per yard), and 18 m. (59 ft. 5/8 in.) long laid on 25 sleepers, so that very high speeds can be run. The Company intends to run from Piacenza to Bettola in 40/45 minutes instead of the 2 hours 10 minutes taken at the present time.

The line will be electrically operated, using 3 000-volt direct current. Each transformer substation — completely automatic — will be equipped with 2 mercury vapour rectifiers, each of 1 000-kw. power, with automatic voltage regulation, in order to use the energy as economically as possible. The control of the distribution will be centred at the Piacenza substation, in order to reduce the value of the relative peak load.

The rolling stock for the passenger service consists of rail motor cars and trailers with a driving compartment. The multiple control fitted makes it possible to run also with the trailer in front.

The mechanical part of the rail motor cars and the trailers is identical. The total length over buffers in 20.50 m. (67 ft. 3 in.). The headstock and the bogies (supplied by the Fiat Company) are of cast steel of the Commonwealth type.

For the first time, the 3 000-volt electrical equipment has been completely arranged under the floor of the vehicles, without it being necessary to build a high tension compartment.

The electric equipment is self-starting and multiple control; this reduces to a minimum the starting and acceleration time as well as the power used.

The passenger doors are pneumatically controlled; the control, from the leading end of the train, opens or closes all the doors on the right or on the left side.

The electric heating is directly off the high tension.

The total tare weight of the rail motor car so equipped is 54 tons and carried on two bogies. The car can carry 18

first-class passengers and 75 third-class passengers sitting and 100 standing. The running speeds can be as high as 100 km. (62 miles).

The line is equipped with the Ericsson block system signalling arranged for automatic train control, and the line is operated under central control with selector telephones.

The equipment of the track is substantial and modern; the plano-altimetric characteristics adopted are very favourable; the vibration in the interior of the vehicles is reduced to a minimum even at the highest speeds; the travelling times between stations are short; the heating and the lighting of the trains are very satisfactory. All these things make it possible to hope that the public will be led to like and prefer this method of transport. Furthermore, as has already been said, various layouts and certain equipment will make it possible to work the line very cheaply particularly through the reduction in the staff working it. All the electric services starting from the substation where the energy is converted, function without staff.

Conclusions.

The considerations and observations brought out in the second part of the report appear to lead to the following conclusions :

1. The rail motor car, with internal combustion motor, has to be considered as one of the methods of traction which meet modern operating requirements on secondary railways and tramways with little traffic.

2. The principal characteristics of this type of rail motor car should be :

a) high normal running speed higher — at least — than 50 km. (31 miles) per hour on level and straight sections.

b) a high degree of acceleration, which will make it possible to obtain equally high average speeds. This condition is of particular value for railways on which there are many stations, and where it is necessary to work almost a suburban service.

c) a light weight, relatively to the number of seats provided for the passengers.

d) a capacity slightly higher than the normal requirements of the trains with little traffic.

e) a sufficiently powerful motor to haul another vehicle during the hours and days when there is heavier traffic.

f) two drivers' compartments, or only one, but placed in such a position that it is possible with safety to operate the rail motor car or the train in both directions.

3. The use of the rail motor car (with internal combustion or any other type of motor) cannot be considered sufficient in most cases to put light railways and tramways with little traffic into a healthy position in times of crisis or when they are subjected to very heavy competition by road motor services This alteration of the traction system must be accompanied by the necessary modernisation of the equipment and the simplification of the operating methods, to meet the ever growing demands of the public, and in particular to provide fast and frequent trains and moderate rates.

4. Finally it must be recognised that in certain cases the secondary railways and tramways can no longer meet the public requirements so that it would be quite useless to consider the use of rail motor cars and any other modernisation of their installations and working. In these cases it is better to recognise that the task of the railway is ended and that it is better to replace it by a modern system of road motor transport.

Rome, April 1932.

APPENDIX.

Questionnaire relating to Question XIII :

Use of rail motors cars on secondary railway lines.

FIRST PART.

I. — *General characteristics of lines operated by rail motor cars.*

Maximum gradients. Lengths. Curves. Minimum radii. Gauge. How many passenger, goods or mixed trains run daily on each line ?

II. — *Particulars of the rail motor cars.*

a) Do you use rail motor cars driven by steam, by accumulators, by internal combustion motors, or by other means ?

b) Type of motor. General characteristics. Power.

c) Brief description of the vehicle.

Number of seats — number of standing places.

Luggage compartment.

Postal compartment.

Weight.

Method of connecting the motor to the frame.

Frame of the vehicle, whether railway or automobile pattern.

Method of suspension.

Clutch.

Transmission whether mechanical, electrical, or other.

Brake.

Heating.

Lighting.

Electric, compressed air, or other type of warning devices.

Driving compartment at one end only, or at both ends.

Method of turning in the case of there being but one driving compartment.

Special equipment.

III. — *Maximum and average speed with and without trailer.*

IV. — *Are the trailer or trailers of a special type ?*

V. — *How many men are used at the same time on a rail motor car ?*

In the event of 2 men being used, does the second help the driver in working the car ?

How is access to the driving compartments obtained ?

VI. — *Does the rail motor car run every day ?*

Do you consider it advisable to send it into the workshops periodically and after what mileage ?

VII. — *Average annual mileage run by the rail motor car.*

Number of days stopped for repairs.

Can the motor readily be removed so that a spare motor can be utilised ?

VIII. — *Nature of the principal defects reported.*

IX. — *Have you carried out tests with rail motor cars having compound wound motor with regeneration ?*

— *With rail motor cars on solid rubber or pneumatic tyres ?*

— *With rail motor cars which are capable of running either on the rails or on the road?*

— *With rail motor cars of some other type ?*

What results have you obtained ?

Results :

a) Consumption of petrol or other fuel per 100 km.;

b) Ditto for lubricating oil;

c) Cost of staff (only including the staff on the vehicle). Indicate the number of employees;

d) Cost of repairs per kilometre;

The figures given correspond to an experience of how many years ?

e) Total cost per kilometre of a rail motor car.

SECOND PART.

1) Do you consider the rail motor car (regardless of the nature and the power of the motive energy) as one of the basic elements in the modern operation of secondary lines ?

2) What are the characteristics that you consider indispensable in rail motor cars to assure the vitality of a secondary railway namely from the point of view of the running speed, of the acceleration, of the weight and of the staff required.

3) Do you consider that a secondary railway line service covered by rail motor cars and including a sufficient number of light and fast trains, is likely to retain the passenger traffic of the line even when there is road competition ?

4) Have you in this case any preferences for rail motor cars of particular features ?

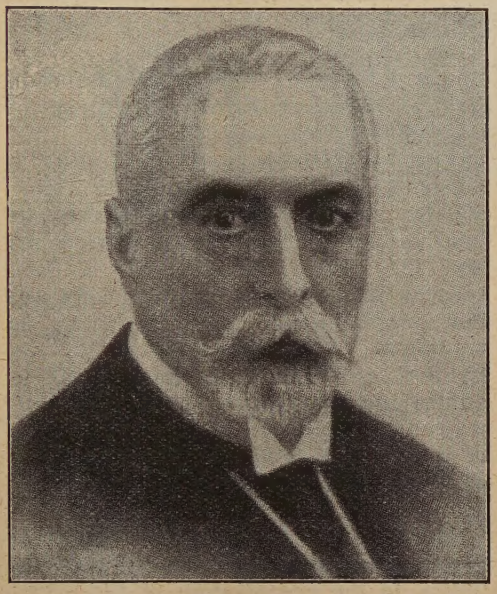
If so, what are they ?

5) Have you any practical information to communicate upon the general problem of the replacing on secondary lines for passenger traffic steam locomotives by electric rail motor cars, accumulator cars, internal combustion motors (petrol, Diesel, etc.) or others ?

OBITUARY.

Don Félix BOIX,

Managing Director of the North of Spain Railways,
Member of the Permanent Commission of the International Railway Congress Association.



We have learnt with much regret of the death of Don Félix Boix Merino, Engineer, Managing Director of the North of Spain Railway Company, member of the Permanent Commission of the Congress. An eminent personality in the railway world, the deceased took a very active part in the Madrid Session. He it was who at the inaugural meeting welcomed the members of the Congress, as President of the Delegation of the Companies to the Higher Railway Council.

Born at Barcelona on the 26 May 1858, Don Félix Boix in 1880 terminated his studies as engineer of roads, canals and harbours. After having occupied various positions in the public services, he commenced his railway career in 1888 when he was put in charge of the construction of the line from Plasencia to Astorga. In 1891 he was made Technical Manager of the Madrid, Cacérès and Portugal Company. In 1904 he joined the North of Spain Company as Assistant Manager, which Company he remained with for the rest of his career. He was appointed Manager on the 1 June 1908. For more then thirty years, during which the railway had to pass through difficult periods, he put at the service of this Company his great qualities both as a man and as an engineer, taking the greatest interest in technical matters, the improvement of the equipment, track and rolling stock, the improvement of the services, the welfare works set up for the benefit of the staff, and in all economic and financial questions. His great ability resulted in his being delegated as counsel for the Central Aragon and the Bilbao to Portugalese Railway Companies and the Saragossa Tramway Company.

Don Félix Boix was also well known for his researches into the history of art. A great collector and critic, he was a member of many Spanish institutions for the protection and development of the fine arts, such as the Prado Museum.

As a member of the Local Organising Committee for the Madrid Congress and Vice-President of the General Office of the XIth Session, Don Félix Boix was deeply interested in the work of the Congress and was among those whose efforts made a success of this Session.

We wish to express our most respectful sympathy to his family.

The Executive Committee.

NEW BOOKS AND PUBLICATIONS.

[313. 385]

STEUERNAGEL (Dr. K.), Reichsbahndirector, Mitglied der Hauptverwaltung der Deutschen Reichsbahn-Gesellschaft. — **Statistik und Eisenbahn** (**Statistics and Railways**). — 1 vol. of 201 pages, with 28 figures and tables. — Berlin W. 9., Verlag der Verkehrswissenschaftlichen Lehrmittelsgesellschaft m. b. H. bei der Deutschen Reichsbahn, Voss Strasse, 6 — (Price : cloth bound, 6.50 Rm. ; paper bound, 5.50 Rm.).

In this book, the Chief of the Statistical Service of the German State Railway Company gives a comprehensive picture of the statistical work undertaken by the railways in general and by the German State Railway Company in particular. He shows how an organisation was evolved for handling figures in such a way as will reflect the activities of these huge undertakings.

Modern conditions have led to great reliance being placed upon statistics. Prior to the war the use of statistics could still be limited to demonstrating the continuous development that was occurring, but in the greatly altered circumstances of the present day, statistics are called upon to deal with the everyday working of the systems and to exercise continuous supervision over it. By grouping and comparing the material that is constantly supplied to it, the statistical service is able to provide an analysis of the conditions at any moment.

By the aid of statistics, railway authorities are able to satisfy themselves, and also the public, as regards the operations, aims, and achievements of their systems, and through the same statistics, material is placed at their disposal that enables them to present the results obtained, in a convincing manner. This statistical work after passing through many phases and undergoing continuous refinement of its methods, has now shown itself to be one of the most valuable means of assisting the daily administrative work, in that it provides accurately and promptly complete information on which to base the consideration of any subject requiring attention.

This book which is entirely free from academic or dogmatic points of view, by its skilful presentation makes us familiar with the fundamental problems and the varied technique of modern railway statistics. A world of figures that might alarm many observers, is made alive and comprehensible in this treatise, for it points out the main ideas underlying the statistical services of railways and shows how the unwieldy mass of individual records is co-ordinated and made to yield results of ever increasing value.

The author devotes special attention to the means of perfecting railway statistics, to the organisation of the statistics of the German State Railway Company, and to the inception and development of that service. The statistical methods of other railways are carefully examined in a comparative and critical appreciation.

This excellent book deserves the widest notice because of the striking and skilled as well as lucid manner in which the various questions are handled. In addition to railway Administrations it will be of special service to those interested in the study of political economy and scientific management in universities and colleges. There is no doubt that it will be of value also to all those whose interests are closely bound up with the railways.